Hungarian Currency: Risk and Devaluation

by

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Abstract

This study provides a multifaceted analysis of the Hungarian currency with data from the last three decades and reflections on the recent shock on the exchange rate posed by Russia's aggression against Ukraine. I investigate through the lenses of balance of payments, international economic concepts, and asset pricing models. Initially, the balance of payments framework was used to explore trends in Hungary's current and financial accounts, highlighting strategic economic shifts post-2010 that impacted the exchange rate too. Subsequently, various parity conditions were tested, revealing significant but incomplete relationships between the exchange rate and factors like interest rates and inflation. The final chapter employed an international asset pricing approach, using a model inspired by the Capital Asset Pricing Model (CAPM) to assess market risk and the risk premium from a US investor's perspective. The findings indicated a negative risk premium for Hungarian investments, underpinned by an event study on market disruptions upon Russia's aggression against Ukraine. This comprehensive analysis offers valuable insights into the complexities of the Hungarian currency, providing a foundation for future research and investment decisions.

Keywords: Hungarian Currency, Exchange Rate, Devaluation, Market Risk Premium,

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Introduction

During Russia's aggression against Ukraine the Hungarian national currency devalued against the US Dollar in historical magnitude. I investigate the overall patterns of the devaluation of the Hungarian Forint with special respect to recent shocks. Discussion on the exchange became central for Hungarian economists. In this study I take a detailed approach to meaningfully contribute to the debate by linking three main components of the fluctuation in the exchange rate: the fundamental pillar of Balance of Payments, concepts in international economics, and an international asset pricing model. By taking data from the last three decades the models applied by this analysis have important explanatory power over the overall variation of exchange rate over time and crucial implications on the recent shock posed by Russia's full-scale invasion.

The Balance of Payments (Chapter 1.) framework is a crucial introductory step in understanding the Hungarian currency. Due to overall issues to test exchange rate variation on Balance of Payments panel data, a descriptive approach is being taken, which serves as the springboard for later chapters. By turning towards concepts in international economics I leave the descriptive approach and turn towards statistical methods to test the specifications of certain parity conditions and models for Hungary (Chapter 2). I include Hungary's Real Effective Exchange Rate, and after estimated I compare it with the potential Equilibrium Real Effective Exchange Rate. I analyse the relationship between interest rates and exchange rates through the Uncovered Interest Rate Parity model. I test the role of inflation differential after deriving it from the International Fischer Effect. I also apply a generalized model of contemporaneous supply and demand for the Hungarian Forint. Finally, I turn to the role that risks and returns can potentially play (Chapter 3.). I adopt an international asset pricing perspective, specifically examining the Hungarian assets from an US investor's point of view. After defining and narrowing down the (international) Capital Asset Pricing Model (CAPM) to market risk premiums, I introduce the term "Hungary Risk Premium" that is the market risk premium on Hungarian market returns that are converted into US Dollars, measured against US risk-free assets, and adjusted to volatility. In such framework I rely on time series GARCH-M technique to account for the time varying nature of the Hungary Risk Premium. Finally, I exemplify Hungary's position by an event study upon Russia's full-scale invasion, which underline the relevance of the concept of Hungary Risk Premium from the perspective of a US investor.

Methodology

This study uses different methodological approaches in each chapter. While the descriptive analysis of the Balance of Payments (Chapter 1.) does not require much clarification, methods for testing the concepts in international economics (Chapter 2.) and the introduction of the asset pricing model (Chapter 3.) might. Most of the concepts of Chapter 2. rely on Ordinary Least Squares (OLS) models, which require stationarity. I took first differences of each variable and conducted Augmented Dickey-Fuller (ADF) tests for stationarity, which can be seen in the Appendix. The Equilibrium Real Effective Exchange Rate estimation relies on a cointegration test, which does not directly require stationary data. The low number of observations in that section reduced the reliability of my estimates. The contemporaneous supply-demand model was a time series Dynamic Conditional Correlation model in the General Autoregression Conditional Heteroskedasticity (GARCH) framework. I also built a linear OLS model, which I declared to be inconsistent due to non-stationarity and serial correlations. Finally, the asset pricing approach in Chapter 3. relies fully on time series modelling: the mean return modelling on the GARCH-in-Mean (GARCH-M), and the volatility modelling on the GARCH (1,1) order.

Literature review

A large part of the literature on Balance of Payments of Hungary are somewhat related to the transition literature and political economic studies. The main theoretical foundations of Balance of Payments are referred from Krugman & Obstfeld (2009); Roubini & Wachtel (1999) connects the implications of transitioning economies on Balance of Payments and Havrylyshyn & McGettigan (1999) underline the departing conditions on subsequent economic outcomes in transition economies. Based on all of that describe Nölke & Vliegenthart (2009) unique pattern of East Central European economies that have implications on current account and capital inflows. Spence (2021) summarises that East Asian success stories and the Washington Consensus have implication on exchange rates. Chapter 2. with international economic concepts reaches to Rogoff (1996) for understanding relative prices and the Purchasing Power Parity. For the equilibrium exchange rate estimation Feyzioglu (1997) and the IMF (2004) is referred for roadmap on the empirical process. For similar purposes Flood & Rose (2002) are quoted when estimating the Uncovered Interest Rate Parity Condition and Abdurehman & Hacilar (2016) for the International Fischer Effect. The contemporaneous supply-demand model originates from Hsing (2016) in the time series specification. Finally, in Chapter 3. by taking an international asset pricing approach, I refer to De Santis & Gerard (1998) who introduced the role of currency risk was introduced in pricing local markets. Multiple applied studies help my attempt in adopting the idea, most notably from Antell & Vaihekoski (2007, 2012). Dahlquist & Sallstrom (2002) summarise the assumptions of conditional and unconditional asset pricing models in the international framework.

Chapter 1: Fundamental Introduction to the Hungarian Currency: the Balance of Payments

The Balance of Payments (BoP) plays a crucial role in exchange rate analysis, yet its predictive capabilities are somewhat constrained. Despite BoP looks like an ideal source of panel data, analyzing exchange rate fluctuations in relation to BoP variations over time present significant challenges, particularly within short time horizons. BoP data is typically aggregated on an annual basis, while exchange rates can exhibit considerable volatility within shorter intervals. This discrepancy can lead to loss of relevant details if exchange rates were to be annualized to align with BoP reporting periods. Consequently, drawing statistically robust conclusions regarding association patterns becomes arduous in shorter-term analyses with limited observations. Additionally, even theoretically, it is uncertain how the nominal exchange rate responds to BoP variations over time. While theory can link the real exchange rate to BoP variations[1], it is not necessarily applicable for the nominal exchange rate. States, in the pursuit of certain political and economic strategies can also override the basic demand and supply logic that the BoP implies on the exchange rate. In my study, I incorporate BoP data to offer descriptive insights into the foundational aspects of exchange rate analysis and to highlight potential trends and contradictions. This inclusion serves as a springboard for the subsequent phases of our analysis.

Balance of Payments, Hungary, and the Exchange Rate

The BoP is a fundamental approach in the analysis of any national currency exchange rate given trade and capital flows. BoP is an annual aggregate balance of four main sub-accounts: current account, financial account, capital account, and official reserves. Accounts categorically collect all observable transactions in an economy and identify them as debit or credit given the direction of the cashflows of transactions. Through the principles of double-entry bookkeeping, the BoP ensures that all transactions balance. The reason why the BoP is referred as a fundamental approach is because its ability to provide insights into the demand and supply dynamics of a currency given the balances on the main accounts. For instance, all else being equal, a surplus in the current account suggest higher demand for a country's good and services. This increased demand for implies higher demand for the country's currency which can lead to nominal exchange rate appreciation (or *vice versa*). The BoP fundamental identity equates the sum of current account, capital account and the financial account to zero. Any contradiction in the BoP has almost certain consequences on the exchange rates.

Hungary's current account balance[2] has demonstrated variation over time between surplus and deficit (Figure 1.), Hungary's more recent turn to current account surpluses coincided with a devaluation of the Hungarian Forint against the US Dollar. Hungary, as other transition

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[1] Chapter 2 also attempts to estimate the Equilibrium Real Effective Exchange Rate (EREER) given current account balance.

[2] The largest component of the current account is trade balance. For Hungary's trade balance see Additional Figure 2. in Appendix.

economies faced current account imbalances. These imbalances[3] were exacerbated by the maintenance of exchange rate pegs, leading to appreciations in real exchange rates (Roubini & Wachtel, 1999:1-2). Consequently, this resulted in a loss of competitiveness, thereby perpetuating trade deficits that peaked during the Global Financial Crisis (Surányi, 2018:126). The unorthodoxy[4] of Hungarian economic policy in the post-2010 era clearly yielded tangible macroeconomic successes (Csaba, 2022:9), exemplified by the attainment of a surplus in the current account. Taking all else equal, Hungary's fluctuating current account balance and consequent changes in the net foreign assets position[5,6] have shown an ambiguous relationship with the exchange rate. However, a more consistent, albeit theoretically contradicting[7] trend emerges in the post-financial crisis period, during which Hungary maintained current account surpluses, resulting in a highly positive net foreign assets position and parallel devaluation of the HUF against USD.

Financial account balance by definition mirrors[8] the balance on current plus capital accounts (Figure 1.), consequently, Hungary experienced fluctuation between a state of being net borrower and net lender in terms of capital flows. In addition to its role in equating the fluctuations in the current and capital accounts, the financial account is significant on its own, as it tracks capital flows from foreign direct investments (FDI) and portfolio investments. Historically, for former socialist economies like the Hungarian, liberalization presented an opportunity to alleviate capital scarcity by attracting[9] international investments (Havrylyshyn & McGettigan, 1999:257-258). By the late 1990s, it became evident that East Central European economies, following prevailing policy recommendations[10], had institutionalized the inflow of foreign capital into their economic frameworks (Bohle & Regan, 2021:87). This regionally widespread feature is frequently

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[3] Roubini & Wachtel (1999) underline that the major threat for transition economies in maintaining current account deficit arise from the imbalance between national saving and domestic investments plus the accumulation of debts. The underlying logic is as follows:

$$\text{Saving} + \text{Investment} = \text{Current Account} =$$
$$= \text{Resource Balance (Net Exports)} + \text{Factor Income} + \text{Current Transfers}$$

[4] The term unorthodoxy is a normative declaration of governor of the Hungarian National Bank, György Matolcsy for the post-2010 policies (Bloomberg, 2013).

[5] Textbooks in economics highlight that current account balance significantly impacts a country's net foreign assets position: when a country experiences a surplus in its current account, it becomes a financier for other nations with deficits; conversely, if a country has a current account deficit, it seeks foreign financing to fulfil its requirements (Krugman & Obstfeld, 2009:296).

[6] See Additional Figure 3. in Appendix.

[7] The maintenance current account surplus, with positive net foreign assets position and subsequent exchange rate devaluation is theoretically contradicting. Dornbusch & Fischer (1980:964) describe an equilibrium, where given current account surplus and positive net foreign asset position is paralleled with appreciating exchange rates in equilibrium for a small open economy.

[8] Current plus capital account deficits need financing and conversely, current plus capital account surplus needs to be invested (Krugman & Obstfeld, 2009:306-307).

[9] Foreign capital entered once the privatization process begun. Havrylyshyn & McGettigan (1999:280-282) point out the overall similarities in the privatization process in East Central European economies, but at the same time they report variation in the speed and the toolkit of privatization process. E.g.: Hungary, to ease the pressure from its massive indebtedness was a forerunner in liberalization and privatization, therefore it welcomed the highest proportion of foreign investments in its privatization process (Kalotay & Hunya, 2000:42).

[10] Spence (2021:77) underlines the policy recommendations of the Washington Consensus with successful cases from East Asia.

described as the dependent market economy model[11] (Nölke & Vliegenthart, 2009:674-679). Foreign investments, either direct or portfolio signal demand for Hungarian currency, however, it is more likely to manifest in market indices rather than the exchange rate, as it has been the case already in the 1990s (Szapáry & Jakab, 1998:709-710).

Figure 1.

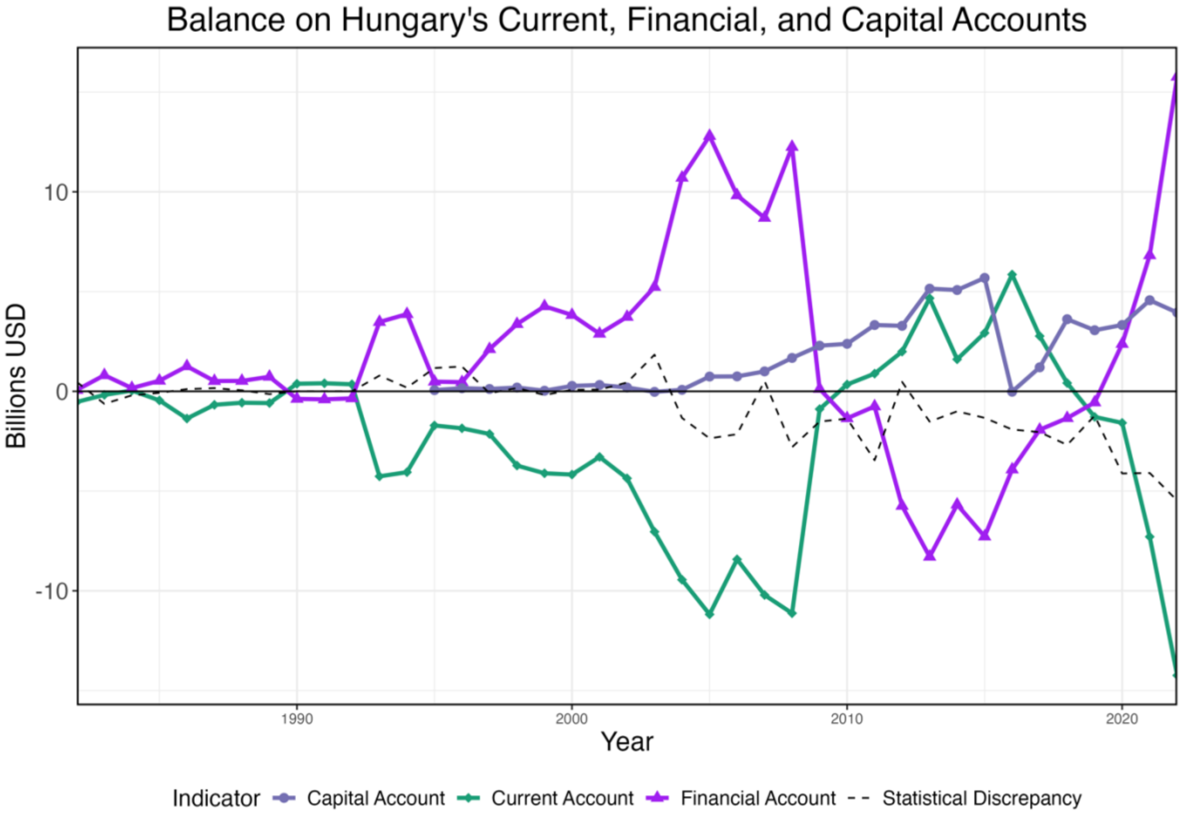

Figure 1. demonstrates the fundamental BoP identity and the variation of components over time.
(Current Account + Financial Account + Capital Account = 0)
Data has been available from 1982, the latest observations are from 2022. BoP is annually recorded and displayed in billions of USD. The statistical error term is also added with dashed line, which equates the discrepancy of the three main components to zero. Note that Capital Account data is only available from 1995. The data (including error terms) is from World Bank.

Official reserves have shown increase (with an episode of significant reduction[12] around 2014-2015) since the early nineties which has eventually been paralleled with the devaluation of the exchange rate (Figure 2.). The exchange rate regime can indicate the extent to which central banks accumulate foreign exchange reserves, and changes in the size of their portfolios can influence exchange rates[13]. Hungary's adherence to an exchange rate peg in the early 1990s distorted competitiveness due to the overvalued exchange rate (Roubini & Wachtel, 1999:1-2). The confidence in the Central Bank if it can defend such strong exchange rate was also

[11] "Varieties of Capitalism" literature originates from Hall Soskice (2001) who initially distinguished the characteristics of the continental/German and the Anglo-Saxon varieties.

[12] In 2014, the Central Bank liquidated a large chunk of its reserves as it proceeded with the conversion of household "FX-Loans" (IMF, 2015:41).

[13] By increasing the portfolio of official reserves (mostly consisting of assets denominated in major currencies) the monetary authorities, all else being equal, increase the supply of national currency which implies depreciation.

questionable, given the relatively small portfolio of reserves[14]. The implementation of a crawling peg gradually stabilized balance of payments issues and initiated a devaluation of the currency (Szapáry & Jakab, 1998:694). In 2008, Hungary adopted a freely floating exchange rate, which remains in place as of 2024 (MNB, 2024). During this period, the Hungarian Forint devalued against major currencies, coinciding with a shift in the current account balance to a surplus and a significant increase in the Central Bank's reserves portfolio, reflecting the Central Bank's accommodative stance towards government policies. One can argue make the argument that the Central Bank has been seemingly supportive as it accumulated large reserves despite being under no direct pressure[15] to do so in a free-floating regime.

Figure 2.

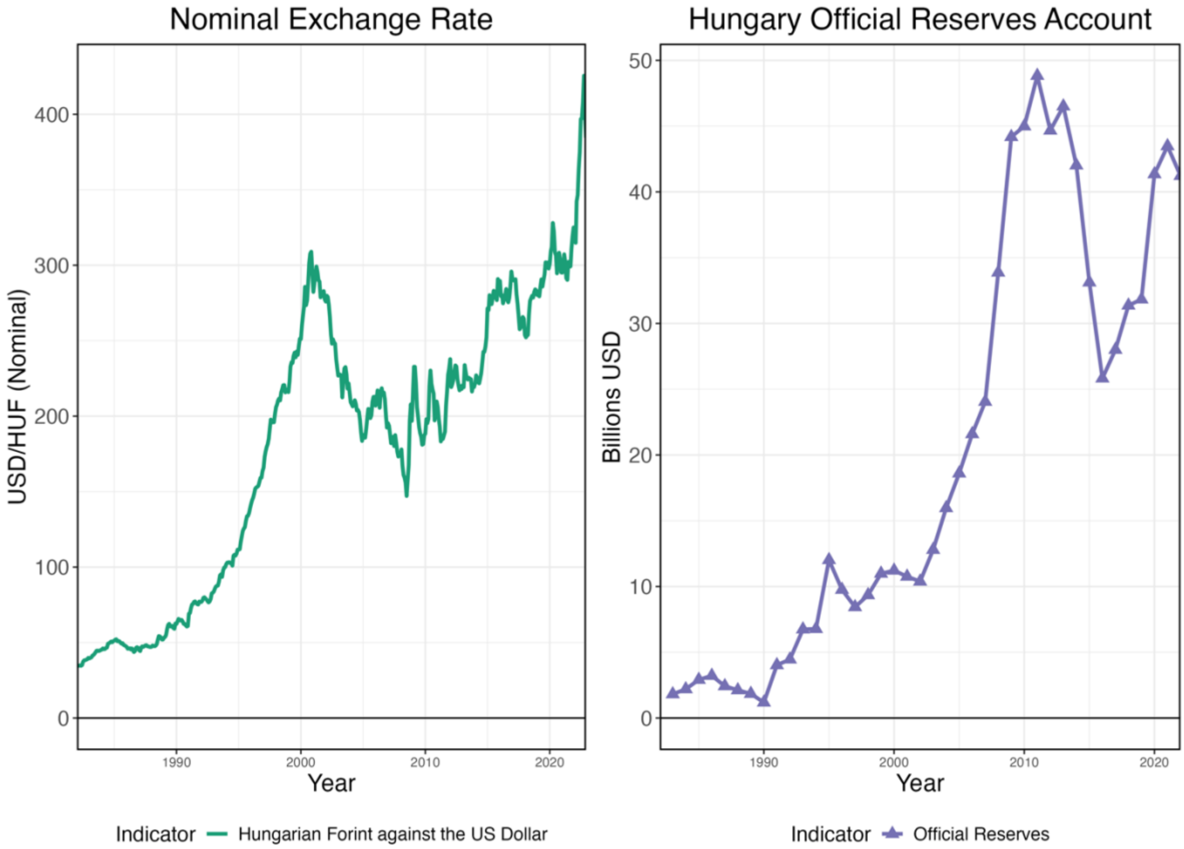

Figure 2. shows two graphs. On the left-hand side the nominal (monthly) exchange rate is displayed against the US Dollar (USD/HUF is a conventional expression or 1 unit of USD displayed in HUF units). The right-hand side shows the official reserves of the Hungarian Central Bank (displayed in billions of USD, annually). Data is taken for identical time periods for the two variables, starting from 1982 until 2022. The source the nominal exchange rate data is the Federal Reserve Bank of St. Louis, the official reserves are taken from World Bank.

[14] As Krugman (1990:574) lay down the framework of the constraint that smaller economies might face when being short of official reserves. Those overlap with Hungary's experience throughout the 1990s.
[15] There exist other incentives for central banks to maintain or increase their reserves portfolios: the IMF's (IMF, 2015:10) report on Hungary underlined fiscal reasons and appropriate target reserves levels (adequacy ranges) in the aftermath of debt crisis.

Recent shocks

Recent exogenous shocks adversely affected the Hungarian currency, amid Russia's aggression against Ukraine the devaluation became salient. Current account surplus maintained during most of the 2010s shifted to deficit around 2019. The deficit deepened during Russia's aggression, as the commodity price shock and Hungary's resource dependence[16] on Russian hydrocarbons implied growth (in absolute terms) in the debit side of the current account. Regarding the capital flows, it seems plausible that Russia's aggression and subsequent macroeconomic instability induced a large-scale sell-off of financial assets in Hungarian markets. Investors not only retreated from Hungary but shifted towards safe-haven currencies, more broadly. Consequently, the US Dollar appreciated, consistent with the logic of Gopinath & Stein (2021:873-875). Furthermore, due to overlapping crises since the Covid pandemic high inflation (pass-through) has been a key issue that dominated discussion among Hungarian economist and government officials. What is certain, is that Hungarian currency devalued more than most of the emerging market currencies in 2022 (Cohn-Bech et al., 2023:12).

In this chapter I aimed to introduce the Hungarian currency through a fundamental lens. After introducing the concept of Balance of Payments (BoP), I examined trends in flow of goods and services on the current account and trends in capital flows in the financial account. Although, there may be coinciding patterns in the nominal exchange rate and current account balance, they presented theoretical contradiction for Hungary. Specific fluctuation in the financial account, such as foreign direct investment and portfolio investments are more likely to manifest in market indices rather than in the exchange rate. Official reserves introduce a new dimension of potential political and economic strategies that Hungary might pursue, given its free-floating exchange rate regime and increasing exchange rate reserves. One can reasonably argue that the current account surplus (and, by definition, a shift to net lender status in the financial account) in the post-2010 period, along with nominal exchange rate devaluation, maintenance, and increase in the official reserves aligns with a strategic departure from the troubled legacy of the 1990s. BoP is far from being the full story; without incorporating concepts that can relate relative prices, interest rate differentials, inflation differentials between Hungary and abroad, any discussion on the Hungarian currency remains incomplete.

[16] Bouzarovski et al. (2016:1156) confirm Hungary's dependence, especially on Russian fossil fuels, and suggest the term "energy poverty" describe the Hungary's position.

Chapter 2: Exchange Rate Related Concepts from International Economics

In this chapter I take an analytical turn towards concepts in international economics, by describing and testing certain parity conditions. Additionally, I adopt a general simultaneous demand-supply prism to understand the association of major economic indicators and the exchange rate. In the previous chapter, I introduced the concept of Balance of Payments and gave insights on the variation of its components in Hungary over time. With these fundamentals established, this chapter takes more precise steps to not only describe but to test some key relationships. First, I examine the Real Exchange Rate of Hungary, I reflect on conclusions from the previous chapter and, I compare Real Exchange Rate with potential Equilibrium Real Effective Exchange Rates. Following the discussion on the Real Exchange Rate, I analyse interest rates and their relationship with the exchange rate. This includes introducing and testing the well-known Uncovered Interest Rate Parity model for Hungary. I also test the relationship of inflation rate differences and exchange rate, which I derive from the International Fisher Effect. Before concluding the chapter, I take a general model of contemporaneous supply and demand to test the association of the exchange rate with key economic indicators.

The Real Exchange Rate

Competitiveness and Real Exchange Rate (RER) are essential concepts from international economics that create a logical link between dimensions of price levels (Ghosh et al., 1997:3-4), international trade and economic growth (Eichengreen, 2007:7-10; Rodrik, 2008). The RER is defined as the ratio of prices of two countries adjusted by the nominal exchange rate[17]. Under the assumptions of Purchasing Power Parity (PPP)[18], exchange rates are expected to fully adjust to price levels, however, once PPP conditions are eased, discussion of competitiveness becomes relevant. There is a good reason to believe that PPP does not hold for the nominal exchange rate as shown by Figure 3. Competitiveness[19] is a term that connects the RER with international trade environment. Since RER relates relative prices or unit labor costs[20], the shift in RER has strong implications to foreign competitiveness: real appreciation distorts competitiveness, real devaluation fosters competitiveness.

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[17] Real exchange rate (RER) is expressed as: RER= $\frac{eP}{P^*}$, where (e) is the nominal exchange rate of 1 USD in HUF units (USD/HUF), (P) is the price level in the USA, and (P*) is the price level in Hungary.

[18] Rogoff (1996:347-348) summarizes the PPP concept: once converted into a common currency, national prices should be equal. The proposition underlines a long-run relationship, with currencies converging to the parity with high volatility in the short run. The "PPP puzzle" is the contradicting magnitude of such short-term volatility and the speed of convergence.

[19] Competitiveness is formalized as follows: $q = \frac{\Delta e \times \Delta P}{\Delta P^*}$. Now in relative terms, (Δe) shows the change in nominal exchange rate, (ΔP) is the change of price level in the USA, and (ΔP*) is the change of price level in Hungary. Under PPP such ratio would equal to 1.

[20] Lipschitz & McDonald, (1992) highlights the difference and weaknesses of methods of RER calculations like the Consumer Price Index (CPI) based and the Unit Labor Cost (ULC) based. Despite certain shortcomings, the CPI and ULC remain the most widely used approaches.

Figure 3.

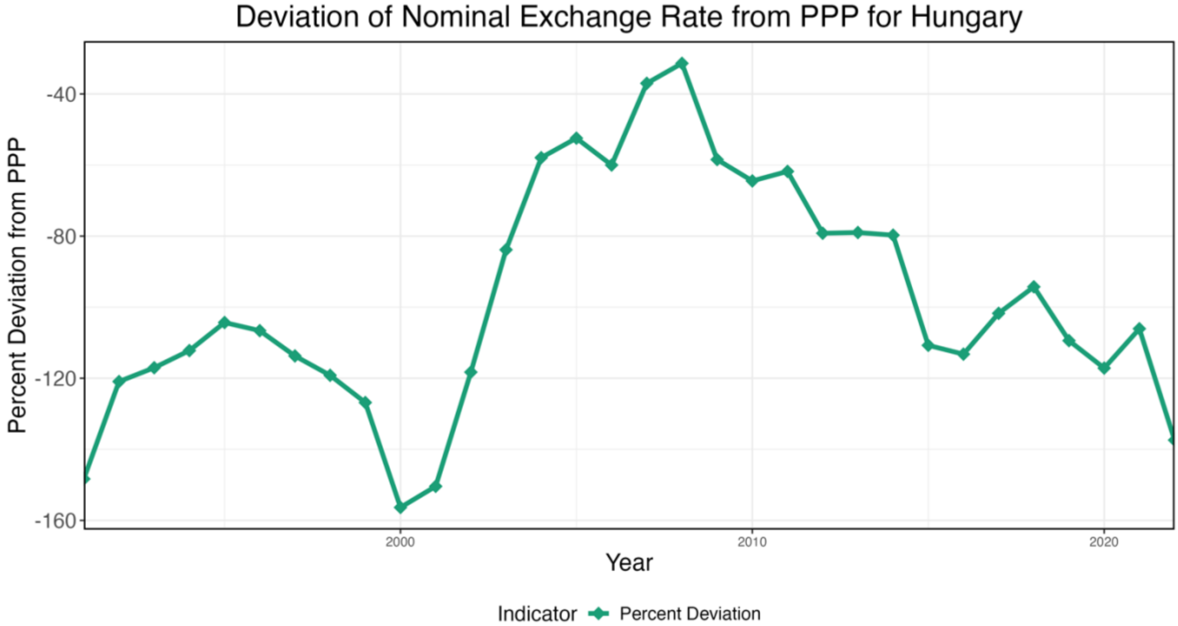


Figure 3. shows the percentage deviation of the nominal exchange rate from the PPP implied exchange rate. In line with the convention, nominal exchange rates that are higher than the PPP implied rate are considered as undervalued and therefore displayed with negative deviation (and *vice versa*). The units are expressed in HUF, conversion of USD. The PPP implied exchange rate is a conversion factor that controls for price difference between countries. Another (narrower) version of the concept, the Big Mac Index applies the same concept for one single globally available product (Economist, 2024). The data is from World Bank.

Hungary experienced a shift from real appreciation only in the late 2000s (Figure 4.). Since than the Real Effective Exchange Rate (REER) has shown consistent depreciation. The REER is a convectional measure against the weighted average of other RERs based on the major trading partners of a country (World Bank, 2024). Regarding the context of its fluctuation, as noted in Chapter 1, Hungary's economic transition from the socialist economy, market by current account deficits and exchange rate peg, coincided with appreciating real exchange rate and distorted competitiveness. Conversely, the post-2010 period, characterized by the free-floating currency regime and current account surplus is associated with real depreciation and competitiveness gains. This is visible on Figure 4., which shows Hungary's REER index over time based on the CPI and ULC approaches. The two approaches exhibit similar outcomes in REERs, both depict the above-described trends.

The Equilibrium Real Effective Exchange Rate

The Real Effective Exchange Rate (REER) has been deviating from the estimated Equilibrium Real Exchange Rate (EREER) as shown on Figure 5. on average by -11.16%, although the model must be considered with caution given the limited statistical significance of results (Table 1.). The long-run EREER is defined as the level consistent with economic fundamentals and external balance (Feyzioglu, 1997:3). First, the estimation of the EREER has been done using the framework of cointegration analysis, similarly to IMF (2004) country report. The underlying econometric model calculates the equilibrium Real Effective Exchange Rate (REER) by using a cointegrating vector. This vector is applied to a combination of the natural logarithm of the REER, the normalized net foreign assets (NFA) position, and the natural logarithm of total factor productivity (TFP)[21]. Specifically, the model multiplies each component by its respective coefficient from the cointegrating vector and sums these products that yields the EREER[22]. Second, the actual REER is subtracted from the deviation from the EREER which results in Figure 5. Annual frequency of the data makes the estimation statistically weak, since only 29 consecutive years contain observation for the above-mentioned variables. The low number of observations threatens the reliability of the model, the results still suggest that the real effective

Figure 4.

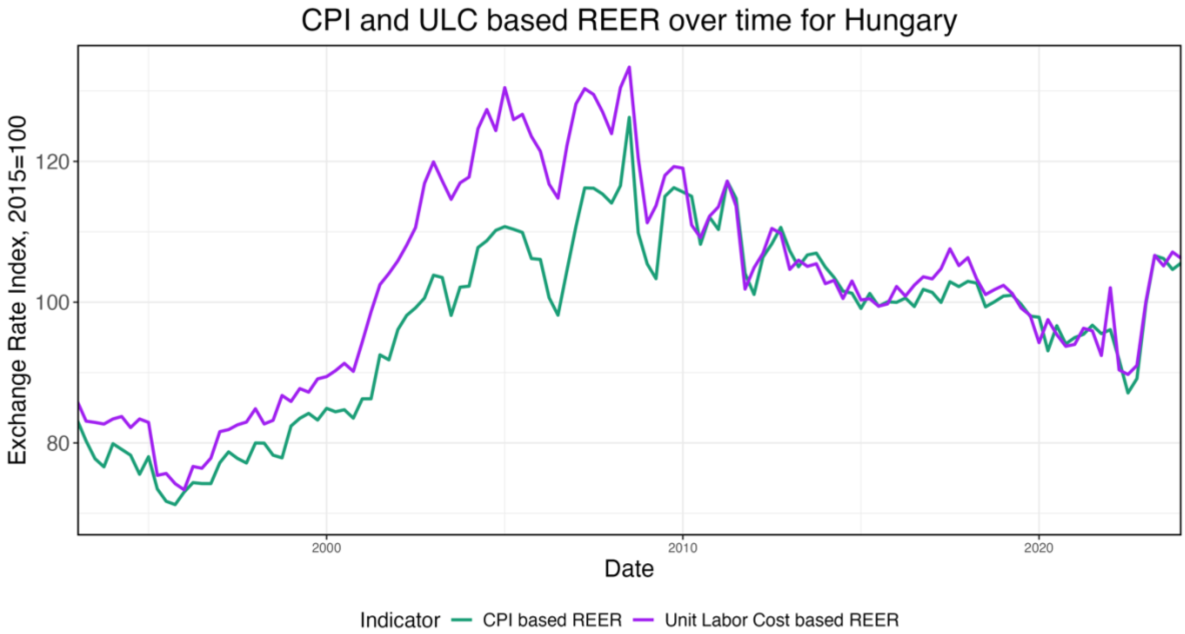


Figure 4. shows CPI and ULC based Real Effective Exchange Rates (REER) over time for Hungary. The values are indexed for 2015 levels. Note that REER appreciation is visible through a positive slope, and conversely, REER devaluation is indicated by negative slopes. This a conventional way of visualizing fluctuation in REER[23]. Data is quarterly frequency; first observations are from 1993. The source of the data is Federal Reserve Bank of St. Louis.

exchange rate is consistently undervalued throughout the entire timespan.

The statistical and economic interpretation of the cointegration test based on Figure 5. and Table 1. and goes as follows. First, the Table 1. summarises the results Johansen cointegration test, which affirms significant cointegration only at the 10% level. The null-hypothesis of the Johansen-test that there are no cointegrating relations[24] between the variables of the model. The trace statistic is 25.53, which is higher than the critical value at the 10% significance level but lower than at 5% level, suggests at least one[25] cointegrating vector. The mean eigenvalue, which indicate the

[21] Total Factor Productivity is a neoclassical economic concept that measures productivity considering all factors of production (assuming that labour is not the only input) (Felipe, 1999:4; Hulten, 2001).
[22] The EREER is plotted, see Additional Figure 5 in Appendix.
[23] For comparing REER and Nominal Effective Exchange Rate (NEER) see Additional Figure 4.
[24] The trace statistic that suggests the number of cointegrating vectors. H_0: r=0 (r is the number of cointegrating vectors.
[25] At 5% and 1% significance levels, there is not enough evidence to suggest more than one cointegrating vector.

strength of cointegration relationship from between 0 and 1 (1 being the strongest) a value of 0.31 with standard deviation of 0.24 indicate a relatively weak cointegration relationship. Based on the statistics, I have somewhat weaker evidence that for cointegration, which might be the result of low number of observations. Despite the weaknesses in the statistical model one can still provide economic interpretation based on the results. Figure 5. shows deviation from the estimated EREER and the actual REER, which is derived from Additional Figure 5. (Appendix). It states that the REER has undervalued compared to the EREER. Some key intuitions, for instance that the EREER appreciates for positive shocks in current account[26] (terms of trade) and total factor productivity are confirmed (similar to Feyzioglu, 1997:20-21; IMF, 2004). Also the fact that the REER deviates from EREER is not surprising, however, confidence in my estimations arises as the REER is not moves in a way that it would correct disequilibria. The relative distance of the EREER and REER in my estimates is also moderately trustworthy, which probably roots in the above-mentioned issues related to weaker statistical reliability.

Table 1.

Test Statistics and Critical Values

Statistic	N	Mean	St. Dev.	Min	Max
Test_Statistics	3	25.53	18.14	8.77	44.78
Critical_Values_10pct	3	24.10	14.33	10.49	39.06
Critical_Values_5pct	3	26.67	15.14	12.25	42.44
Critical_Values_1pct	3	31.72	16.13	16.26	48.45

Eigenvalues

Statistic	N	Mean	St. Dev.	Min	Max
Eigenvalues	4	0.31	0.24	-0.00	0.55

Table 1. Contains the relevant statistics for the Johansen cointegration analysis. The "Test Statistics and Critical Values" section collects the critical values at certain levels of significance, which can be compared with the test statistic. Below that the eigenvalues table can be seen. The cointegrating relationship is summarized as follows:

$$log\_REER_t = \beta_1 nfa_t + \beta_2 log\_prod_t$$

(The estimating equation is put in a VAR Vector Autoregressive Model)

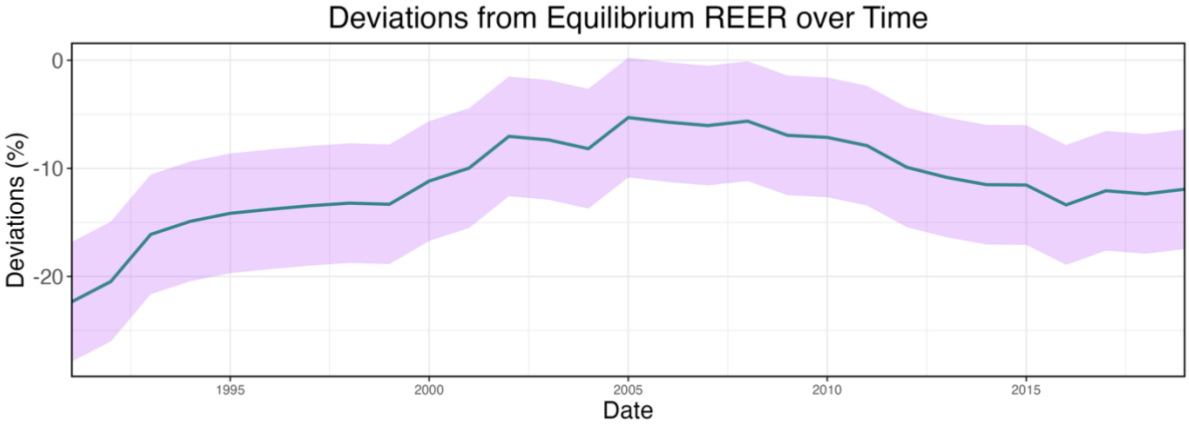
where *nfa* is the net foreign assets (normalized by GDP) which is calculated by cumulative summation of current account balances over time (obtained from the World Bank); and *prod* is the total factor productivity (in natural logarithms) (obtained from the Federal Reserve Bank of St. Louis).

If the results have some reliability, the question arsises, what does the persistently undervalued REER apply. First, if the REER fluctuates around the EREER and converges to it, it is not a case misalignment. Misalignment, overvaluation or undervaluation, must be persistent, which as Edwards (1989:94-95) suggests, the costs of diverging from equilibrium has empirically been parallelled with severe negative effects on output and growth. Hungary's case suggests sustained undervaluation, which potentially implies economic overheating and pressure on domestic prices (Jongwanich, 2009:1-2); however, the sustain undervaluation could have an important factor in current account surplus maintenance and competitiveness gains. The potential aftermath of the

[26] See Chapter 1. on BoP: seemingly coinciding variation on current account balance and levels of EREER.

disequilibrium could have gained more serious negative effect as the recent shocks unfolded and hit Hungary and current account balance to match capital flows were not generated as Williamson (1983:49) proposed.

Figure 5.



Summary Statistics for Deviation

Statistic	Mean	Min	Max
Deviations	-11.16	-22.38	-5.30
CI_Upper	-5.63	-16.85	0.23
CI_Lower	-16.70	-27.91	-10.84

Figure 5. Shows the deviation of the REER from the estimated EREER in %, with 90% confidence interval bands. The deviation is summarised by the summary table below the graph, the underlines that the REER has consistently been undervalued, on average, by -11.16%. In 2005 it got close to the EREER, deviating only by -5.3%, meanwhile in 1991, the deviation was the biggest: -22.36%.

Interest Rates Differences: the Uncovered Interest Rate Parity Condition

The analysis on Uncovered Interest Rate Parity shall begin with the introduction of the Covered Interest Rate Parity (CIP), which serves as the cornerstone of understanding the relationship of interest rates and exchange rates across different countries. CIP establishes a fundamental no-arbitrage condition. For example, consider an investor with Hungarian Forints who wishes to invest for period "T". Initially, the investor can undertake two paths: deposit Hungarian Forints for a period "T"; or exchange Hungarian Forints on the spot market for US Dollars and then earn deposit for period "T" in US Dollars. Those two possible paths are connected by a currency forward for time "T", that converts Hungarian Forint earned by time "T" into US Dollars (*or vice versa*). Assuming that the deposits are default-free and there is no counterparty-risk for the forward contracts, the initial two investments and the forward contract results in equivalent payoffs if compared in the same currency (Du et al., 2018:916). Theoretically, it is assumed that any mispricing in the no-arbitrage framework would cancel out almost individually, however, there is increasing evidence[27] that there are persistent arbitrage opportunities (Baba & Packer, 2009:13-14; Du et al., 2018:952-953; Liao, 2020:1-5).

[27] Most of the studies that showed sustained deviation from the no-arbitrage condition, highlighting that the cost of intermediaries, default risk and periods of financial turbulence matters highly for the deviation to hold.

Figure 6.

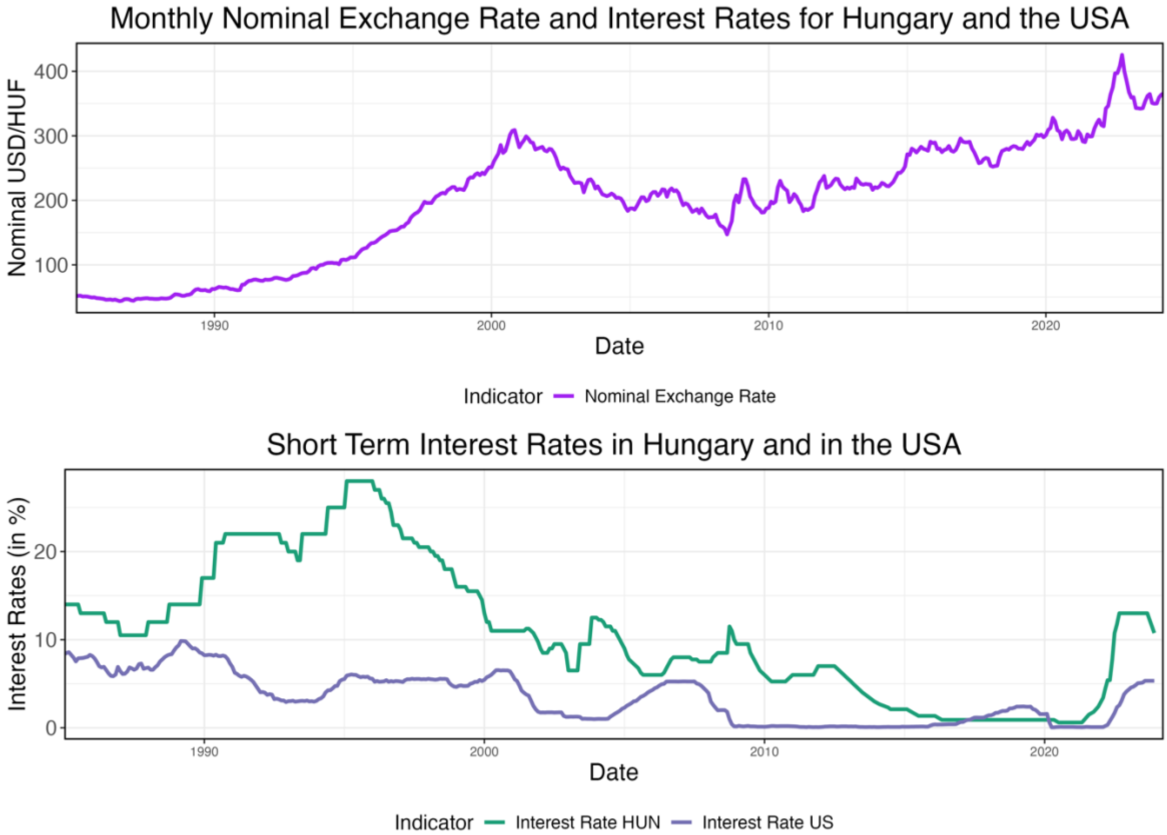


Figure 6. shows two graphs: above the nominal exchange rate (1 USD in HUF units) over time; and the graph below contains two interest rates over time the US and the Hungarian short term interest rates. The data is monthly in both graphs. The source of the data is the Federal Reserve Bank of St. Louis.

UCIP proposes that the interest rate differential is on average equal to the ex-post exchange rate changes. High yield currencies are expected to depreciate, while all else being equal, real interest rate increases can appreciate the currency (Flood & Rose, 2002:252-255; Bekaert et al., 2007:1-3). Testing the UCIP typically involves an Ordinary Least Squares (OLS) model[28]. The null-hypothesis suggests that H_0: $\alpha=0$ and $\beta=1$, where the β coefficient captures the correlation of interest rate differential between domestic and foreign yields, and the outcome variable is the ex-post exchange rate. The UCIP's statistical validity and economic intuitions has been contradicting ("UCIP puzzle"). Empirical evidence offered the opposing relationship, disproving the null-hypothesis (Ismailov & Rossi, 2018:242-245). For instance, during the in 1980s, and

[2828] The UCIP technical aspects (following Flood & Rose, 2002:3):

$$(1 + i_t) = (1 + i'_t)E_t(S_{t+\Delta})/ S_t$$

where "i" is the domestic (Hungarian) interest rate at time "t"; " i' " is the foreign (US) interest rate at time "t"; "E_t" is the expected (ex-post) change in the exchange rate between "t + Δ" and "t". After log transformations:

$$E_t(s_{t+\Delta} - s_t) \approx (i - i')_t$$

were "$s_{t+\Delta} - s_t$" is the difference between log exchange rate in "t + Δ" and "t". In my model, interest rates are also taken in natural logarithms yielding a log-log elasticity OLS model which is parametrized as follows:

$$(s_{t+\Delta} - s_t) = \alpha + \beta(i - i')_t + \varepsilon_t$$

1990s high-yield currencies tended to appreciate (Lothian, & Wu, 2011:488-492). Meredith & Chinn (1998:3) argue that potentially the failure of the UCIP might be due to time varying risk premia.

Despite the empirical low confidence in the UCIP, for Hungary the nominal exchange rate positive and significant results for monthly (and also quarterly time horizons[29]) as Figure 7. and Table 2. suggests. The results from the OLS indicate that: first, the constant is statistically not different from zero at the conventional significance levels; second, the beta coefficient that captures the response to changes in the interest rate differential between Hungary and the US is positive and significantly different from zero at the 5% significance level. The interpretation of the results goes as follows: 1% increase in the interest rate differential (logarithmic) is on average associated with 5.7% increase in the ex-post exchange rate (logarithmic differences). The significant result is underpinned by the relatively long time span and monthly frequency in the data. The overall predictive power of the model remains low, only single digit percentage variation in the nominal exchange rate is explain by the variation in the interest rate difference. The reason why the monthly UCIP model is considered as primary source of significant correlation is because of the sample size that is considerable higher than for quarterly frequencies (N=396 vs. N=160 respectively) based on which the monthly frequencies are preferred for more precision. However, the UCIP is a longer-term concept that theoretically that might favour the quarterly frequencies. Regardless of the decision on sample size, in neither of the cases (monthly and quarter) are the beta coefficients equal to 1, as the H_0 of the UCIP would suggest it.

Figure 7.

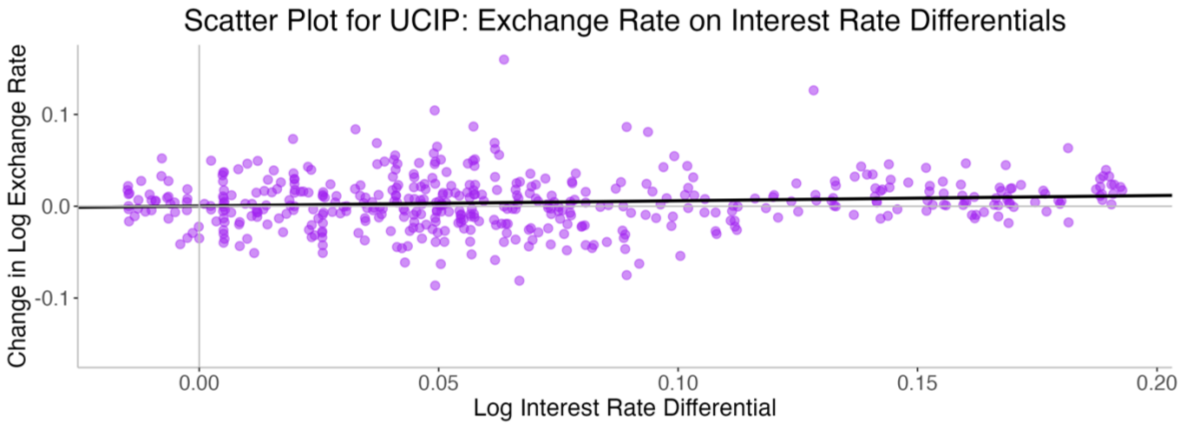


Figure 7. is a scatter plot that shows outcome values of change in the log exchange rate (ex-post changes) given variation in the log interest rate differential in monthly frequency. A linear line is fitted on the observations, which has the slope coefficient from the OLS model (Table 2.). The source of the data is the Federal Reserve Bank of St. Louis.

[29] See Additional Figure 6. and Additional Table 4. in Appendix which shows the scatter plot and regression results for quarterly frequency.

Table 2.

OLS model for UCIP

	Dependent variable:
	Change_log_Exchange_Rate
Log_Interest_Rate_Differential	0.057**
	(0.025)
Constant	0.0001
	(0.002)
Observations	396
R^2	0.013
Adjusted R^2	0.011
Residual Std. Error	0.028 (df = 394)
F Statistic	5.359** (df = 1; 394)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 2. shows the results from the UCIP estimation from an OLS model. The outcome variable is the ex-post exchange rate differences and the regressor is log interest rate differential. ADF test on residuals for proving stationarity is provided by Additional Table 2. in Appendix. The source of the data is the Federal Reserve Bank of St. Louis.

Inflation Rate Differences: an Indirect Insight from the International Fischer Effect

The International Fischer Effect (IFE) theory suggests that changes in the exchange rates are linked to interest rate differential across countries. Similarly to the proposition of the UCIP, the IFE predicts that high yielding currencies are expected to depreciate against lower yielding lower yielding countries' currencies. However, a key difference between the UCIP and IFE lie in the framework: UCIP focuses solely on interest rates, the IFE incorporates inflation into its analysis. The IFE suggests that nominal interest rate difference between countries is a good predictor of ex-post exchange rate differences (Jaffe & Mandelker, 1976:447-448). The expectation arises because higher nominal interest rates tend to reflect higher anticipated inflation. Domestically, the Fisher Effect proposes that the nominal interest rate can be broken down to the sum of the real interest rate and the expected inflation, therefore higher inflation expectations induce higher nominal interest rate (Fisher, 1930; Evans & Lewis, 1995:231-232). This is the relationship that can link inflation rate differences across countries to the exchange rate in the IFE framework (Abdurehman & Hacilar, 2016:1455-1456). Interest rate differentials across countries root in the differences in inflation expectations, thus a country with higher inflation expectation typically have higher nominal interest and the currency is expected to depreciate (or *vice versa*).

Figure 8.

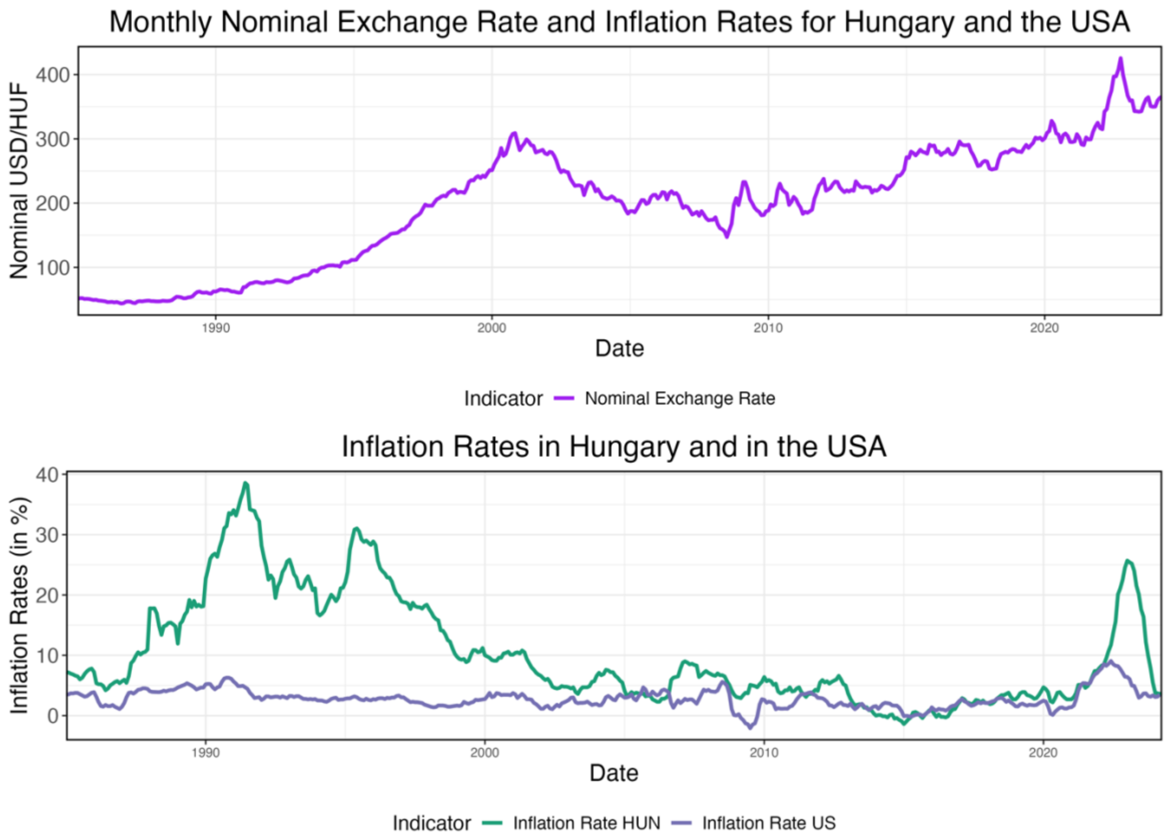


Figure 8. shows two graphs: above the nominal exchange rate (1 USD in HUF units) over time; and the graph below contains two inflation rates over time the US and the Hungarian short term interest rates (growth rate same period previous year). The data is monthly in both graphs. The source of the data is the Federal Reserve Bank of St. Louis.

After testing the empirical formulation[30] of the IFE for Hungary, the results suggest positive and significant relationship of inflation rate differences between Hungary and the US with the nominal exchange rate (1 USD in HUF units) as Figure 9. and Table 3. indicate it. The results from the OLS indicate that: first, the constant is statistically not different from zero at the conventional significance levels; second, the beta coefficient that captures the response to changes in the inflation rate differential between Hungary and the US is positive and significantly different

[30] The IFE framework goes as follws: domestically, the Fisher Effect states that:

$$(1 + i_t) = (1 + r_t)E_t(\pi_{t+1})$$

where "i" is the nominal interest rate at time "t", "r" is the real interest rate at time "t", and "E" is the expectation at time "t" of inflation "π" for "t+1". Similarly to UCIP, once we transform expectation for the exp-post exchange rate and compare differentials across countries, firs the nominal interest rate suggest the following:

$$E_t(s_{t+\Delta} - s_t) \approx (i - i')_t$$

where after log transformation "$s_{t+\Delta} - s_t$" is the difference between log exchange rate in "t + Δ" and "t", and the interest rate differential between home and foreign country becomes proportional. Holding other variables constant, substituting the inflation rate differences between home "π" and foreign country "π'" yields the following proportionality:

$$E_t(s_{t+\Delta} - s_t) \approx (\pi - \pi')_t$$

In my model, inflation rates are also taken in natural logarithms yielding a log-log elasticity OLS model which is parametrized as follows:

$$(s_{t+\Delta} - s_t) = \alpha + \beta(\pi - \pi')_t + \varepsilon_t$$

from zero at the 5% significance level. The interpretation of the results goes as follows: 1% increase in the inflation rate differential (logarithmic) is on average associated with 3.5% increase in the ex-post exchange rate (logarithmic differences). The significant result is underpinned by the even longer time span than for the UCIP model and monthly frequency in the data. The overall predictive power of the model remains low, only negligible percentage variation in the nominal exchange rate is explain by the variation in the inflation rate difference (R^2. The result also provides and indirect form of correlation between inflation rates and interest rates (UCIP results) validating the logic of the IFE.

Figure 9.

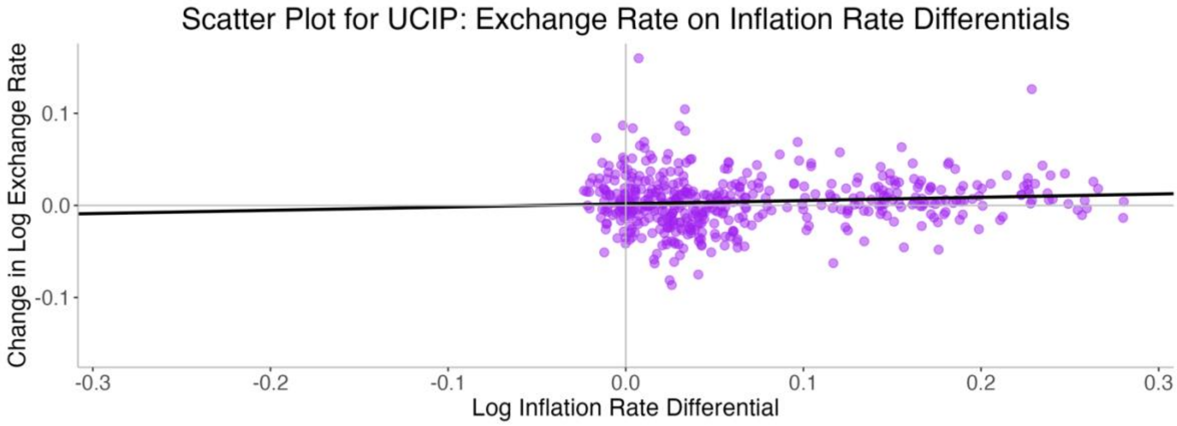


Figure 9. is a scatter plot that shows outcome values of change in the log exchange rate (ex-post changes) given variation in the log inflation rate differential in monthly frequency. A linear line is fitted on the observations, which has the slope coefficient from the OLS model (Table 3.). The source of the data is the Federal Reserve Bank of St. Louis.

Table 3.

OLS model for IFE

	Dependent variable:
	Change_log_Exchange_Rate
Log_Inflation_Rate_Differential	0.035**
	(0.018)
Constant	0.002
	(0.002)
Observations	470
R^2	0.008
Adjusted R^2	0.006
Residual Std. Error	0.028 (df = 468)
F Statistic	3.984** (df = 1; 468)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 3. shows the results from the IFE estimation from an OLS model. The outcome variable is the ex-post exchange rate differences and the regressor is log inflation rate differential. ADF test on residuals for proving

stationarity is provided by Additional Table 3. in Appendix. The source of the data is the Federal Reserve Bank of St. Louis.

Supply-Demand Model for the Hungarian Currency

This section attempts to establish a simplistic supply-demand model for the Hungarian currency based on Hsing (2016), however, our results differ substantially. The main motivation is to examine if text-book examples about certain economic scenarios are in fact related to exchange rate variation or not. In contrast to similar study, I find little certainty that significant time-varying association exist between variables defined by the supply and demand framework. The supply-demand for the Hungary currency model set-up and the toolkit is taken from Hsing (2016) who defined supply and demand variables and applied an Exponential – General Autoregression Conditional Heteroskedasticity (E-GARCH) model. I apply the supply and demand functions defined by Hsing (2016:165-166), but I change the E-GARCH model to a Dynamic Conditional Correlation (DCC) model provided by the General Autoregression Conditional Heteroskedasticity (GARCH) framework. Initially the GARCH was meant to monitor levels of volatility over time, allowing for heteroskedasticity. The multivariate DCC specification allows for time-varying correlation estimation between multiple time series. After defining the supply and deman dunctions, tha variables are pooled in to the time series framework. The results of the DCC-GARCH suggest significant dynamic correlations only of US stock returns (log_US_Stock_diff), Hungarian stock returns (log_HU_Stock_diff) and the expected exchange rate returns (log_Expected_Exchange_Rate_diff) with the actual exchange rate returns (log_Exchange_Rate_diff). This is fundamentally different from Hsing (2016:168), whose coefficients are mostly singificant, although his sample size is alarmingly low.

The model which relates the demand for and supply of the US Dollar vs Hungarian Forint goes as follows (based on Hsing, 2016: 165-166). Demand for US Dollars[31] is defined as a function of the exchange rate (spot USD/HUF, 1 USD in HUF units), real economic output of Hungary, interest rates in the US, stock prices in the US, expected exchange rate (USD/HUF, 1 USD in HUF units), and inflation in the US. Supply for Hungarian Forint[32] is defined as a function of the exchange rate (spot USD/HUF, 1 USD in HUF units), real economic output of the US, interest rates in Hungary, stock prices in Hungary, and inflation in Hungary. Once the equilibrium

[31] Demand for US Dollars is described by:

$$D=X(E,Y^{HU},R^{US},S^{US}, E^{e}, \pi^{US})$$

Where: E is the actual exchange rate (1 USD in HUF units); Y^{HU} is the Hungarian real GDP; R^{US} is the interest rate in the US (T-bill); S^{US} is the stock price index in the US; E^{e} is the expected exchange rate, which is created from averaging exchange rate levels of previous four quarters (1 USD in HUF units); and finally π^{US} is the inflation rate in the US. All those variables are quarterly, (log) first differences are taken.

[32] Supply for Hungarian Forint is described by:

$$S=X(E,Y^{US},R^{HU},S^{HU}, \pi^{HU})$$

Where: E is the actual exchange rate (1 USD in HUF units); Y^{US} is the Hungarian real GDP; R^{HU} is the interest rate in Hungary on short term assets (matched to T-bill); S^{HU} is the stock price index in Hungary; and finally, π^{HU} is the inflation rate in Hungary. All those variables are quarterly, (log) first differences are taken.

exchange rate is expressed[33] it is assumed that variation in the exchange will be a functional outcome of the nine exogenous variables. *Ceteris paribus* comparisons and intuition suggests that higher growth in Hungarian real GDP could imply increasing demand for investments[34] in the US which is thereby expected to correlate negatively with the exchange rate (and *vice versa* for higher US real GDP growth). Interest rates and inflation rates may have multiple interpretation. Given the previous section that discussed the UCIP and IFE, it can be expected that interest rate and inflation for Hungary is positively correlated with the exchange rate (and *vice versa* for the US). Stock prices growth in Hungary is expected to strengthen the Hungarian Forint, therefore it would correlate negatively with the exchange rate. However, I must declare that the exogeneity assumption is undermined as potentially most of these variables have spill-over effects: for instance, Hungarian stock prices are expected to correlate highly with US stock prices. Real GDP trends are suggesting common business cycles which than also relate to interest rates and inflation. All in all, the model performs poorly for various reasons, although, some of the intuitions are still confirmed.

After taking hundred subsequent quarters (from 1999) for ten different sections, testing a supply-demand model for the Hungarian Forint and US Dollars, I find little evidence that the model variables would have convincing predictive power over the exchange rate in this time varying framework (Table 4., Table 5.). Using a larger sample, nearly double the size of Hsing (2016) (N=100 vs. N=58) alters my results significantly. Furthermore, the exogeneity assumptions appear to be weakly founded. It seems that it is only the stock prices in the US and Hungary that correlate with the exchange rate significantly (besides the expected exchange rate which is created from the lags of exchange rate). This suggest that variations in Hungarian stock prices are highly correlated with variations in US stock prices, indicating a potential spill-over effect. If we consider the results of Table 4 reliable, the fact the only the stock price variables are significant might imply that in free-floating currency regimes, financial markets may have a stronger time-varying relationship with exchange rates than conventional fundamental variables, which have been tested throughout Chapter 2. This does not imply that concepts from international economics are not relevant, but they are likely to be more effective over the long term. Meanwhile, Hsing (2016:168-169) claims long run equilibrium relations of the nine fundamental variables and the exchange rate (Table 4.). However, this claim is not without controversy, given the tools used. To assert a long-run equilibrium relationship between the nine variable and the exchange rate, a cointegration test[35] is recommend rather than the DCC GARCH

[33] The equilibrium exchange rate is expressed as follows:

$$\overline{E} = \overline{E}\,(E^e, Y^{US}, Y^{HU}, R^{US}, R^{HU}, S^{US}, S^{HU}, \pi^{US}, \pi^{HU})$$

[34] It would be reasonable to link GDP growth to current account surplus and to net foreign assets position (or just to the financial account) which would induce net lender position. Net lenders seek investments abroad, therefore the demand for US investments can be linked to Hungarian real GDP growth.

[35] The Johansen cointegration test results for the supply-demand model confirm long-run equilibrium relationship, with multiple cointegrating vectors and the test statistic is highly significant. See Appendix, Additional Table 6.

Table 4.

Summary of DCC GARCH Supply-Demand model

	Correlation_with_log_Exchange_Rate_diff	P_Value
log_US_Real_GDP_diff	0.0000	0.8895
US_Interest_Rate_diff	0.0000	0.9987
log_US_Stock_Price_diff	-0.0017***	0.0000
US_Inflation_Rate_diff	-0.0001	0.7028
log_HU_Stock_Price_diff	-0.0022***	0.0000
HU_Interest_Rate_diff	0.0001	0.7202
HU_Inflation_Rate_diff	0.0000	0.9878
log_HU_Real_GDP_diff	-0.0002	0.4902
log_Expected_Exchange_Rate_diff	0.0008**	0.0072
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 3. collects the correlation coefficients from the DCC GARCH times series model. In this specification, the coefficients are showing correlation with the log exchange rate difference

Table 5.

Relationship of the listed variables with the exchange rate (1USD in HUF units)									
	E^e	Y^{US}	Y^{HU}	R^{US}	R^{HU}	S^{US}	S^{HU}	π^{US}	π^{HU}
DCC GARCH	(+)	?	(-) (n.s.)	?	(+) (n.s.)	(-)	(-)	(-) (n.s.)	?
OLS[36]	(+)	+ (n.s.)	(-) (n.s.)	(+) (n.s.)	(+)	(-)	(-) (n.s.)	(+) (n.s.)	(-)
Non-significant coefficients are coded as (n.s.).									

Table 5. shows the sings of the coefficient estimates from two different models and indicates significance of the coefficients. The two models are not directly comparable as they rely on different assumption, however their results are indicative.

Recent Shocks

The economic slowdown induced by the Covid pandemic and the commodity shock with contrasting direction amid Russia's aggression in 2022 had impact on most of the model outcomes introduced by this chapter. First, the nominal exchange rate became increasingly undervalued compared to the PPP implied exchange rate. Second, there has been a RER appreciation in the aftermath of Russia's aggression. Real appreciation was achieved through relative price levels channel (as Hungary experienced highest inflation rates in the region), which ultimately coincided with competitiveness losses and a shift to current account deficit in the BoP. Third, even if the EREER model has shown considerable weaknesses during estimation, it has

[36] See Additional Table 5. in Appendix. The reason why it has not been considered as a consistent model is because of the serial correlation what the OLS cannot address.

been consistent with the implications of the reversal in external balance, therefore it suggested lower equilibrium level. The actual REER's deviation from the
equilibrium widened in the period of recent shocks. Fourth, the UCIP model, implied high devaluation of the Hungarian Forint (against US Dollar) in nominal terms as the interest rate differential widened as much as 10.44% points at its maximum in 2022-09-01. Fifth, the derived relationship of inflation differentials from the IFE suggested similar devaluation dynamic as the UCIP because inflation rate differences between Hungary and the US were as high as 11.89% points in the same period of 2022-09-01. Time-varying supply demand currency model underlined the importance of stock markets as potential predictors of exchange rate, which accurately suggested devaluation dynamics amid major stock market selloffs both in the US and Hungary.

This chapter left the descriptive framework of the Balance of Payments analysis and introduced a variety of concepts from international economics, which have been applied and tested on Hungary. I examined the Real Exchange Rate of Hungary, I reflected on conclusions from the previous chapter and, I compared Real Exchange Rate with potential Equilibrium Real Effective Exchange Rates. The equilibrium estimation faced considerable statistical weaknesses which provided low precision for calculating deviations from the equilibrium level. Following the discussion on the Real Exchange Rate, I analized interest rates and their relationship with the exchange rate. I concluded that the Uncovered Interest Rate Parity model had positive and significant estimates for the exchange rate (however, far less than 1). I also tested the relationship of inflation rate differences and exchange rate, which I derived from the International Fisher Effect. Similarly to the Uncovered Interest Rate Parity condition, the International Fisher Effect remained positive and significant (however, far less than 1). I adopted a general model of contemporaneous supply and demand to test the association of the exchange rate with key economic indicators, which contrasted the findings of similar study and rejected the idea of overall significance of all time varying relations.

Chapter 3: International Asset Pricing and the "Hungary Risk Premium"

This chapter takes a distinct approach from the preceding ones by examining the Hungarian currency through the lens of international asset pricing. Previous chapters analysed fundamental concepts and parity conditions in international economics, which while useful, proved limited in explaining exchange rat fluctuation. The final section of Chapter 2. hinted time varying (negative) correlation between exchange rate and capital market returns, but this relationship was not adequately explored. In this chapter, I shift focus towards risks and returns, aiming to assess Hungary's position from the perspective of a US investor. I develop a model inspired by the well-known Capital Asset Pricing Model (CAPM), extending it into an international context. Although the CAPM was originally designed to estimate returns on individual assets, my analysis concentrates on market risk and the market risk premium on US and Hungarian markets, linking them through the exchange rate, which introduces an additional complexity. The risk premium that US investors face might be discouraging or encouraging effects on investing in Hungarian market. The concept of the "Hungary Risk Premium" has gained traction among investment professionals, particularly considering Russia's aggression against Ukraine, subsequent selloffs in Hungarian markets and the devaluation of the Hungarian Forint against the US Dollar. To quantify the Hungary Risk Premium, I employ time series model, specifically the GARCH-M, a widely utilized technique in studies with similar objective. Finally, I illustrate the recent episode of exogenous shock–Russia's aggression–to exemplify how Hungary's disadvantageous position manifest in capital markets.

Prices of Risks in Hungary over time

Before establishing the model to explain the Hungary risk premium, it is essential to describe some of the major risk factors that Hungary faces (Figure 10.). I fit GARCH-M models[37] separately to three different time series: World Market Risk[38], Local Market Risk[39], and Currency Risk[40]. Using monthly data, the risk prices estimate as monthly conditional standard deviations. While summing these and annualizing them involves significant simplifications and must be approached with caution, it provides a useful perspective on the magnitude of annual risk, which

[37] The main parametrization of the GARCH-M model's mean and variance equation. The mean equation goes as follows:

$$r_t = \mu + \lambda\sigma_t^2 + \varepsilon_t$$

where "r_t" shows the return on a certain asset at time "t"; "μ" is a constant term; "λ" is a coefficient that measures the impact of conditional volatility on mean return; "σ_t^2" is the conditional variance at time "t"; and finally, "ε" is the error term at time "t". The variance equation, which follows the common GARCH (1,1), models "σ_t^2" conditional variance:

$$\sigma_t^2 = \omega + \alpha\varepsilon^2_{t-1} + \beta\sigma^2_{t-1}$$

where "σ_t^2" shows the conditional variance at time "t"; "ω" is a constant term; "α" coefficient measures the impact of past "t-1" squared residuals (that is the ARCH component); "β" coefficient measures the impact of past "t-1" conditional variances (that is the GARCH component).

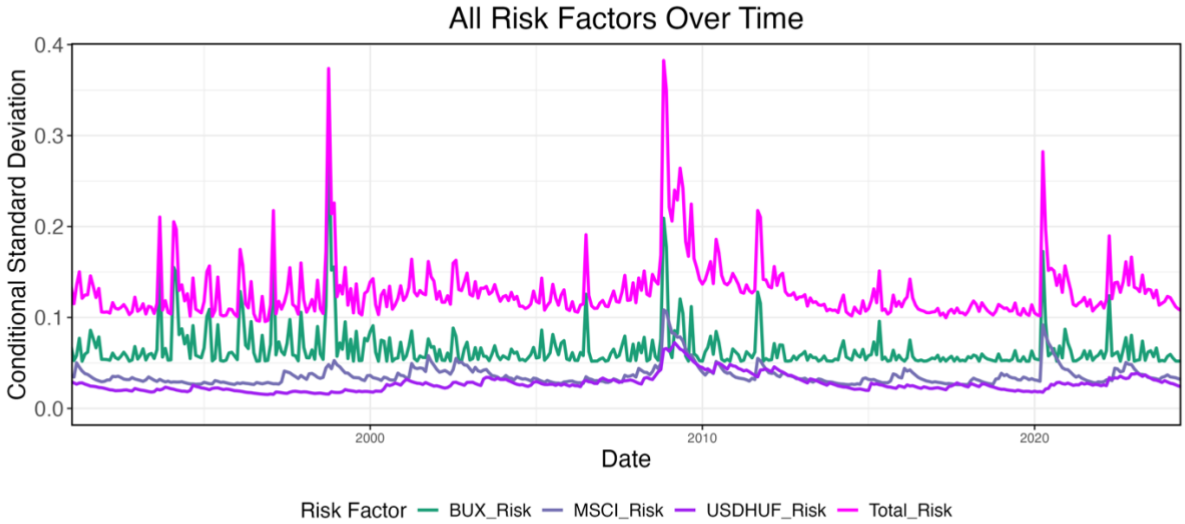
[38] The World Market Risk (MSCI_Risk) is proxied by the MSCI World Index (monthly frequencies, starting from 1991-01, obtained from Yahoo Finance).

[39] The Local Market Risk (BUX_Risk) is proxied by the Hungarian Share Price Index (monthly frequencies, starting from 1991-01, obtained from the Federal Reserve Bank of St. Louis).

[40] The Currency Risk (USDHUF_Risk) is proxied by the exchange rate of 1 USD in HUF units (monthly frequencies, starting from 1991-01, obtained from the Federal Reserve Bank of St. Louis).

are conventionally displayed on an annual basis. The results depicted in Figure 10. and the descriptive statistics indicate that monthly, the Local Market's average risk price was 6.54%, whereas the Currency's average risk price was around half of that, at 3.64% over the period of 400 months. The World Market Risk is included as a benchmark; while other studies directly assess its impact on Local Market Risks, I have simply added it to the Local and Currency Risk prices to illustrate its magnitude. Over a year, these monthly estimates can accumulate into significant volatility, especially in the case of the Local Market (annualized 22.6%), while Currency Risk remains lower implying relative exchange rate stability (annualized 9.5%).

Figure 10.



Summary Statistics of Monthly Average Risk Prices

	Mean	Min	Max	Std.Dev
Avg_BUX_Risk	0.065	0.052	0.309	0.024
Avg_MSCI_Risk	0.036	0.026	0.108	0.011
Avg_USDHUF_Risk	0.027	0.015	0.072	0.010
Avg_Total_Risk	0.129	0.096	0.382	0.034

Mean of Annualized Average Risk Prices

	Mean
Mean_BUX_Risk	0.226
Mean_MSCI_Risk	0.125
Mean_USDHUF_Risk	0.095
Mean_Total_Risk	0.447

Figure 10. shows different risk price estimates of the Local Market Risk (BUX_Risk), Currency Risk (USDHUF_Risk) and the World Risk (MSCI_Risk). Also, a separate line is provided for the sum of each risk prices. Tables below show the summary statistics of monthly risk prices, from which, the means are compounded to annualized risk prices.

International Extension of Asset Pricing Model: the Discouraging Dynamics of the Hungary Risk Premium

I depart form the Capital Asset Pricing Model (CAPM) and compare the market risk premia of Hungary and the US by accounting for the dimension of the exchange rate and volatility. Initially, the CAPM[41] was designed to relate the expected return on individual assets to the risk-free rate and the sensitivity of the individual assets' return on the market portfolio (Perold, 2004:16). Once the numerous assumptions of the CAPM eased, international dimension may also be introduced. Famously, De Santis & Gerard (1998) created a model, where the role of currency risk was introduced in pricing local markets. Since than multiple applied studies followed the idea such as Antell & Vaihekoski (2007, 2012). More nuanced models emphasize the assumption on the extent to which markets are integrated globally. An international CAPM model in unconditional form states that the expected excess returns on all assets are proportional to the excess return on the world market portfolio, where exchange risk is not priced (Dahlquist & Sallstrom, 2002:3). In contrast, conditional asset pricing is more restrictive and includes separate terms for the currency, with which my method is consistent. I take a more simplistic approach by comparing market risk premia of Hungary and the US. Excess returns in the US and Hungary are not directly comparable. To make the two comparable, one must first account for the exchange rate returns and include a conversion term (Table 11.). The main component of my model is defined by the excess returns on the US market[42], excess return on the Hungarian market[43], and finally, to make them comparable, excess return on Hungarian market converted to US Dollars, measured against the US risk free, that is the Hungary Risk Premium[44].

The results presented in Table 6. indicate short-term negative Hungary Risk Premium. Broadly, within the GARCH-M model framework[45], the (μ) parameter is of particular interest as it represents the risk premium. In this specific context, the intercept term that is defined as the adjusted excess return on Hungarian market by converting it to US Dollar, subtracting the US risk-free from it and accounting for the volatility effect from the GARCH model, captures the average excess return rate, the Hungary Risk Premium. Such average excess return is considered

[41] The CAPM goes as follows:

$$E_i=r_f+\beta(E_M-r_f)$$

where "E_i" is the expected return on asset "i", the "r_f" is the risk-free rate, "β" is a coefficient that captures the sensitivity of asset "i" on the market portfolio, "E_M-r_f" is the excess, return on the market, the market risk premium.

[42] Excess return on US market is defined as:

$$Excess\_SPX\_Returns_t=R_{SPX,t}-R_{US\_RF,t}$$

where the excess return on US market is the return on US market less the risk-free rate in the US.

[43] Excess return on Hungarian market is defined as:

$$Excess\_BUX\_Returns_t=R_{BUX,t}-R_{HUN\_RF,t}$$

where the excess return on Hungarian market is the return on Hungarian market less the risk-free rate in Hungary.

[44] The Hungary Risk Premium is defined as the excess return on Hungarian market converted to US Dollar. First step, Hungarian market returns converted into US Dollars:

$$R_{BUX\_USD,t}=(1+R_{BUX,t})\times(1+R_{USD\_HUF,t})$$

Second step, creating excess returns for the converted Hungarian market returns:

$$Excess\_BUX\_Return\_USD_t=R_{BUX\_USD,t}-R_{US\_RF,t}$$

[45] The estimating equation in the GARCH-M (with GARCH (1,1) specification for volatility modelling) goes as follows:

$$r_t = \mu + \lambda\sigma_t^2 + \varepsilon_t$$

where "r_t" shows the excess returns on Hungarian market in US Dollars; "μ" is the intercept term, it accounts for the average excess returns, the risk premium of the Hungarian market; "λ" is a coefficient that captures the impact of conditional volatility on the mean returns on Hungarian markets; "σ_t^2" is the conditional variance of returns on Hungarian market at time "t"; and finally, "ε" is the error term at time "t".

as the risk premium as it manifests the compensation that investors expect by taking on additional risk with investing in the Hungarian market as opposed to the US risk-free asset. Negative value for the Hungary Risk Premium implies that US investors are better off by avoiding investments in the Hungarian stock market since for their additional risk-taking they can expect lesser returns in the short run. It is crucial to note that the Hungary Risk Premium is estimated monthly. Taking the annualized (compounded) term into consideration might be misleading due to the potential variability of other influencing factors over the long horizon. The excess returns for both the US and Hungarian markets are calculated by matching market returns with the appropriate risk-free yields. Over longer periods, different outcomes for excess returns are expected due to the nature of the yield curve, and exchange rate fluctuations might induce different results for the annual Hungary Risk Premium than simple compounding of the monthly estimates. Given these considerations, while monthly Hungary Risk Premium is confidently estimated at -0.6%, extrapolating this to an annual figure (annualized -7.1%) becomes speculative and should be treated with caution.

Table 6.

GARCH-M Model Parameters

Parameter	Value
mu (μ)	-0.006
archm	-0.926
omega (ω)	0.0003
alpha1 (α_1)	0.140
beta1 (β_1)	0.806
Estimated Monthly Hungary Risk Premium (USD)	-0.006
Annualized Hungary Risk Premium (USD)	-0.071

Table 6. shows the parameter estimates of the GARCH-M model for the excess return series with GARCH (1,1) order on volatility series. The (μ) parameter accounts for the interecept term in the mean equation of GARCH-M model. It is the average excess return, the Hungary Risk Premium (in US Dollars). On average, the Hungarian market had -0.6% monthly excess returns after adjusting for volatility. The "archm" measures the impact of the conditioanal variance on mean returns. It reflects an hihgly inverse relationship (-0.926) of high volatility and lower mean returns. The (ω) parameter is the constant term in the variance equation of GARCH, it is the baseling, non time variant volatility (0.0003). The (α_1) parameter suggesta a modest (0.14) impact of past squared residuals on current volatility. Finally, (β_1) shows high persistent volatility (0.806), periods of high volatility are likely to be followed with periods of high volatility. The GARCH-M has a Maximum Likelyhood Estimation (MLE) underneeth its bonnet. All estimates are monthly, monthly frequencies were taken from 1991-01, 400 subsequent months. See additional plotting on Additional Fiugre 7. in Appendix.

Recent Shocks, an Event Study Example

Russia's aggression against Ukraine provides a critical case study that highlights the disadvantageous position underlying the concept of the Hungary Risk Premium (Figure 11.) The previous section established a framework to conceptualize and operationalize this risk premium. The findings indicate that the negative risk premium for Hungarian excess returns after converting it into US Dollars, subtracting US risk free, and adjusting for the volatility, suggests that US investors are worse off when taking on additional risk in the Hungarian market, as they can expect negative excess returns. From the perspective of US investors, holding Hungarian market portfolio while facing exchange rate fluctuations poses dual threat especially during market crashes or crisis. A relevant example is the full-scale invasion of Ukraine by Russia in 2022, which triggered significant selloffs globally. However, the Hungarian market experienced a more substantial decline compared to the US (and world market index) and simultaneously, the Hungarian Forint continued depreciation against the US Dollar. This scenario underscores the heightened risks and potential losses US investors might face, emphasizing the importance of the Hungary Risk Premium in investment decision-making.

Figure 11.

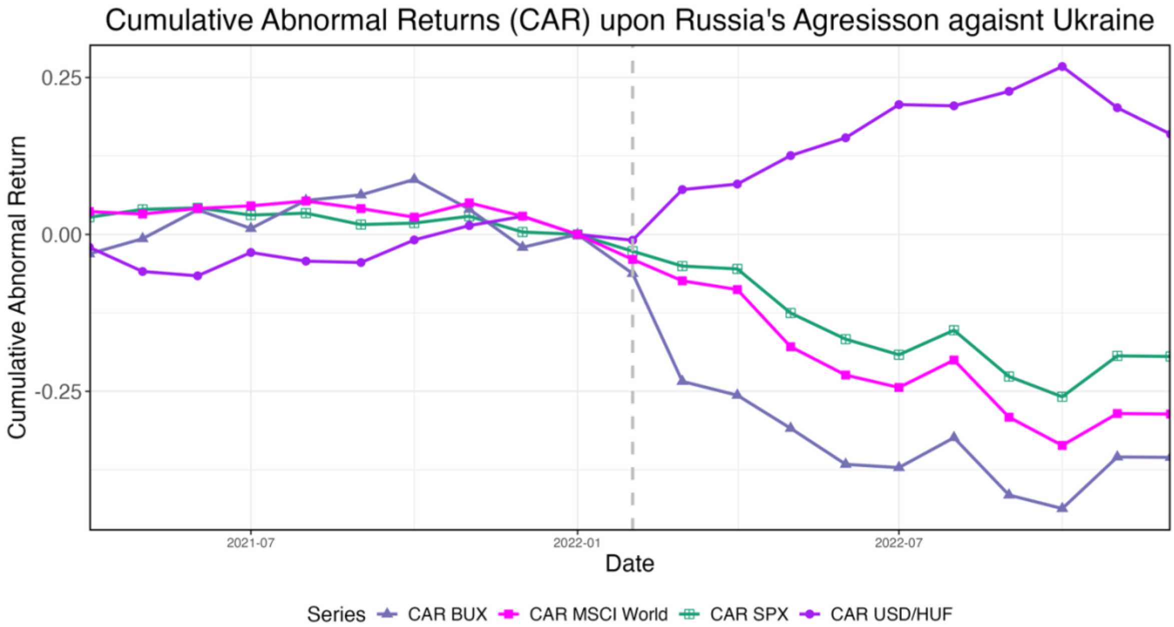


Figure 11. shows the CAR over time for the Hungarian market, the World market, US market and the exchange rate (1 USD in HUF units) for the period after Russia's full-scale invasion. For reliability, only the first three months in the post-event period should be considered. The vertical grey dashed line indicates the month of Russia's aggression against Ukraine.

The Cumulative Abnormal Returns (CAR) from the event study on upon Russia's full-scale invasion suggest the lowest abnormal returns in Hungarian market compared to similar returns of the US and World markets, while the exchange rate produced high cumulative abnormal returns. The event study modelled on Figure 11., aims to assess the impact of Russia's aggression on various market returns and exchange rate. In such framework, abnormal and cumulative abnormal returns account for the effect of an exogenous shock. The event data is set for February 2022, with estimation window of 10 months[46] before the evet date to estimate normal returns[47].

[46] Ideally, the event window would have been set for a larger horizon, however, it could have picked up all the turbulence amid the crisis of the Covid pandemic.

[47] Normal returns for each asset are calculated as the expected returns in the event window:

$$\text{Expected\_SPX\_Return}=\frac{1}{N}\sum_{t=1}^{N}\text{SPX\_Return}_t$$

$$\text{Expected\_BUX\_Return}=\frac{1}{N}\sum_{t=1}^{N}\text{BUX\_Return}_t$$

The post event anormal returns are calculated[48] for 10 months, with relative confidence in in the first three months of after the event[49]. After having abnormal return estimates, one can accumulate those returns[50] to given periods for the post event. The model implies CAR of around -12% for the US market, -18% for the World market, and -30% for the Hungarian market (three months after February). Meanwhile the CAR for the Hungarian Forint against the US Dollar turned out to be around +12%, implying high devaluation three months after the event. This reaffirms, that for exogenous shocks, like Russia's full-scale invasion, holding Hungarian market portfolio poses a dual threat form US investors. The relative is disadvantage that is behind of the negative Hungary Risk Premium is exemplified by this event study.

After leaving the Balance of Payments discussion and testing concepts in international economics, I turned towards an asset pricing approach to gain insights in the role of exchange rate in this chapter. I focused on risks and returns, aiming to assess Hungary's position from the perspective of a US investor. I developed a model inspired by the well-known Capital Asset Pricing Model (CAPM), extending it into an international context. I focused on market risk and the market risk premium on US and Hungarian markets, linking them through the exchange

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$$\text{Expected\_USD\_HUF\_Return}=\frac{1}{N}\sum_{t=1}^{N}\text{USD\_HUF\_Return}_t$$

$$\text{Expected\_MSCI\_World\_Return}=\frac{1}{N}\sum_{t=1}^{N}\text{MSCI\_World\_Return}_t$$

[48] Abnormal returns are calculated as difference between actual returns and and expected returns (based on the before event returns):

$$\text{Abnormal\_SPX\_Return}_t=\text{SPX\_Return}_t\text{- Expected\_SPX\_Return}$$

$$\text{Abnormal\_BUX\_Return}_t=\text{BUX\_Return}_t\text{- Expected\_BUX\_Return}$$

$$\text{Abnormal\_USD\_HUF\_Return}_t=\text{USD\_HUF\_Return}_t\text{- Expected\_USD\_HUF\_Return}$$

$$\text{Abnormal\_MSCI\_World\_Return}_t=\text{MSCI\_World\_Return}_t\text{- Expected\_MSCI\_World\_Return}$$

[49] This event study, CAR framework weakens further away from the treatment, therefore I suggest considering mostly the first three periods after the event.

[50] Creating Cumulative Abnormal Returns (CAR) is done by summing abnormal returns over time for exch series:

$$\text{CAR\_SPX}_t=\sum_{i=t}^{t}\text{Abnormal\_SPX\_Return}_i$$

$$\text{CAR\_BUX}_t=\sum_{i=t}^{t}\text{Abnormal\_BUX\_Return}_i$$

$$\text{CAR\_USD\_HUF}_t=\sum_{i=t}^{t}\text{Abnormal\_USD\_HUF\_Return}_i$$

$$\text{CAR\_MSCI\_World}_t=\sum_{i=t}^{t}\text{Abnormal\_MSCI\_World\_Return}_i$$

rate, which introduced an additional complexity. The risk premium that US investors face when investing in Hungarian market portfolio is negative in the short run. This is a serious discouraging factor for US investors, that might have demand implications on the currency and Hungarian assets alike. I illustrated the recent episode of exogenous shock–Russia's aggression–to exemplify how Hungary's disadvantageous position manifest in capital markets and the exchange rate. Put together, the Hungary Risk Premium notion, that gained traction among investment professionals in Hungary, was conceptualized and operationalized by this chapter.

Conclusion and Policy Recommendation

This study aimed to provide a comprehensive analysis of the Hungarian currency through various lenses, from fundamental Balance of Payments approach, through concepts in international economics to international asset pricing. Main takeaways from the Balance of Payments (Chapter 1.) is that while nominal exchange rate fluctuations and current account balances often coincide, theoretical contradictions for Hungary were evident. It became clear that the weaking Hungarian Forint, partly because of increasing official reserves portfolios of the Hungarian National Bank, and the parallel shift to current account surplus reflect strategic economic policies in the post-2010 period. However, deeper understanding of the Hungarian Forint required integrating concepts of relative prices, interest rate and inflation differentials with international markets. Therefore, I tested various international economic concepts for Hungary (Chapter 2.). I explored the Real Exchange Rate and its potential equilibrium levels, despite encountering statistical limitations. Hungary's sustained (undervaluation) deviation from the Equilibrium Real Effective Exchange Rate implies potential risks in overheating, and output distortions. The Uncovered Interest Rate Parity and the International Fischer Effect (the letter with respect to the inflation rate differences) both showed positive but less than perfect correlations with variation in exchange rate indicating a partial but significant relationship. A contemporaneous supply and demand model reveal limited overall significance, contrasting with previous study, while singled the potentially relevant variables for time varying relationships. The final chapter adopted an international asset pricing perspective, focusing on risks and reruns from a US investor's point of view. By changing the specifications of the Capital Asset Pricing Model, I highlighted the complexities introduced by the exchange rate for cross border investments. The findings indicated a negative "Hungary Risk Premium", the market risk premium of the Hungarian market returns converted to US Dollar, measured against the US risk-free and adjusted to volatility. Negative risk premium implies significant discouraging effects on the demand of US investors for the Hungarian currency and assets in the short run. The event study analysis of Russia's aggression against Ukraine exemplified Hungary's vulnerability in capital markets and exchange rate relative to the US and World markets.

There are no straightforward policy recommendations, however, the conclusions of the analysis underline a complex dilemma on the role of the exchange rate. On the one hand, as it has been argued, the weak nominal and potentially undervalued real exchange rate has played a crucial role in Hungary's shift in competitiveness, and current account surplus. Weak nominal exchange rate has been partially a result of the strategic action of Hungarian monetary authorities, despite fact that in a free-floating regime the are no official targets for the exchange rate. On the other hand, the permanently weak and volatile nominal exchange rate and sensitive local markets create a permanent discouraging factor for foreign investors to acquire Hungarian assets and currency. This if remains, implies a perpetual weaking dynamic on the exchange rate. Therefore, the dilemma on fixing the exchange rate or remaining in free-float is a complex one.

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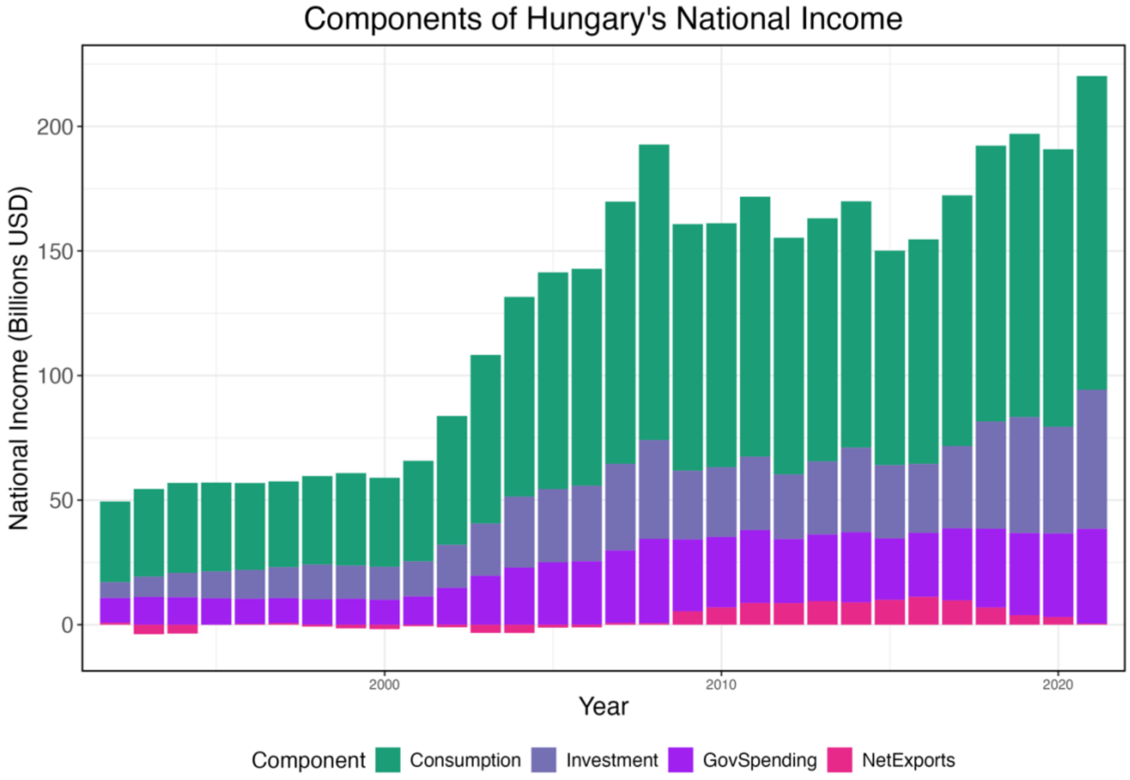
Appendix

The replication package is available at: https://github.com/galamboslajos/CEU_MA_THESIS

Additional Figure 1.



Additional Figure 1. derives the following national income identity:

$$Y = C + I + G$$

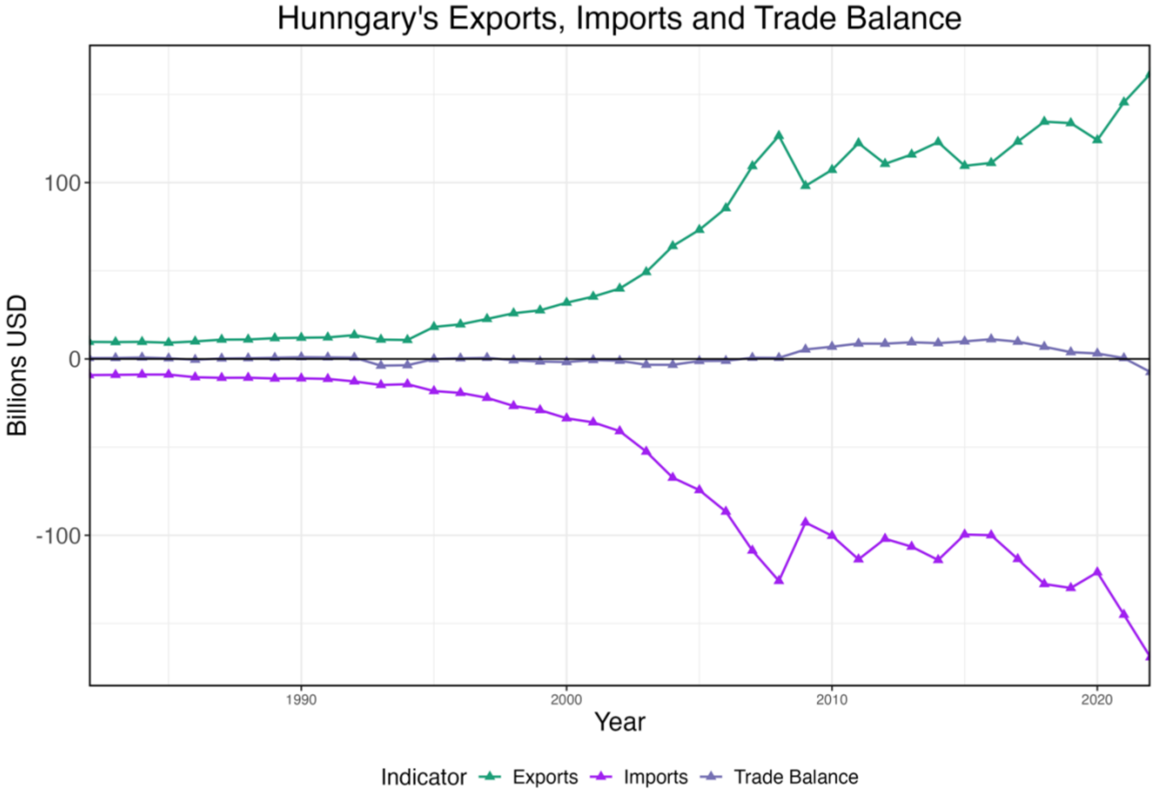
Since Hungary is an open economy, the national income identity is as follows:

$$Y = C + I + G + EX - IM$$

Additional Figure 1. shows the national income of Hungary over time (1991-2021) broken down into constituting units (current USD). It shows that proportion of the net exports component which is discussed in Chapter 1. The decomposition of the national income of Hungary gives insight on the proportions of the components of the national income by using the expenditure approach. To clarify, national income is equal to the gross national product (GNP) less depreciation plus net unilateral transfers. The letter two are ignored given their small magnitude.

Data source: World Bank (https://data.worldbank.org)

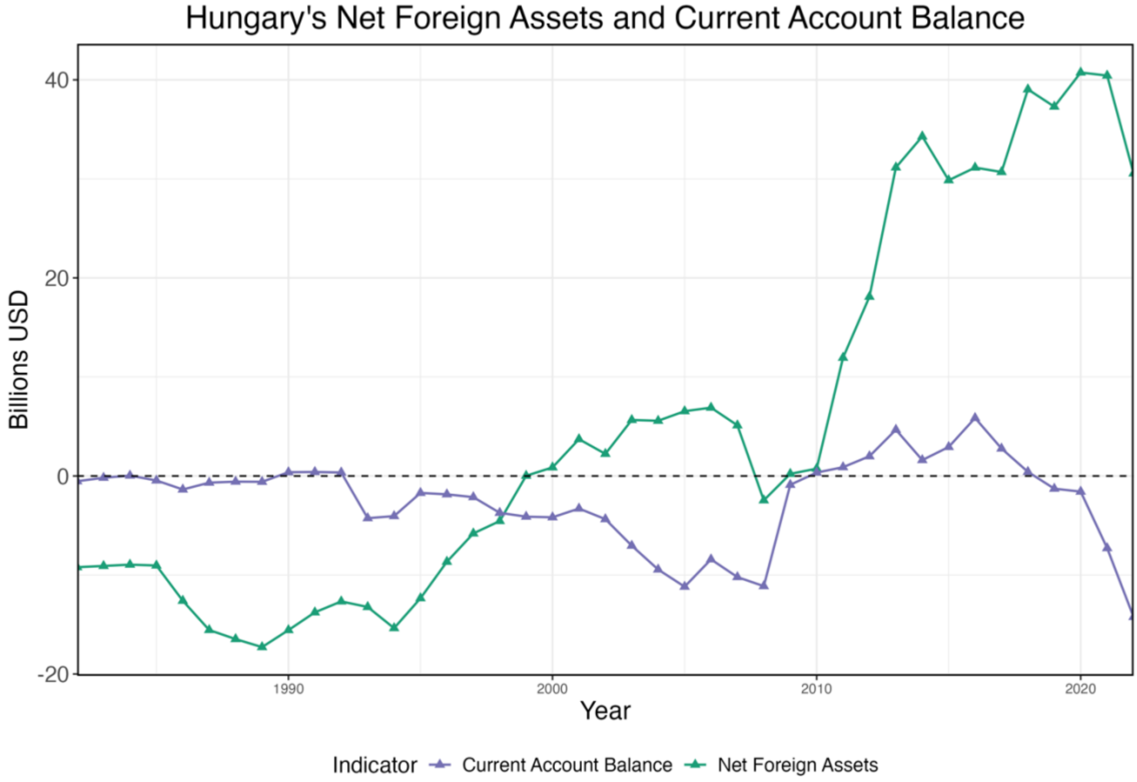
Additional Figure 2.



Additional Figure 2. shows exports, imports, and overall trade balance over time (in current USD). It is visible that trade balance has fluctuated over time between deficit and surplus. The trend of current account surplus ceased in 2022, largely attributed to Russia's aggression, which triggered a commodity shock. This is notably evident in the increased costs of energy imports.

Data source: World Bank (https://data.worldbank.org)

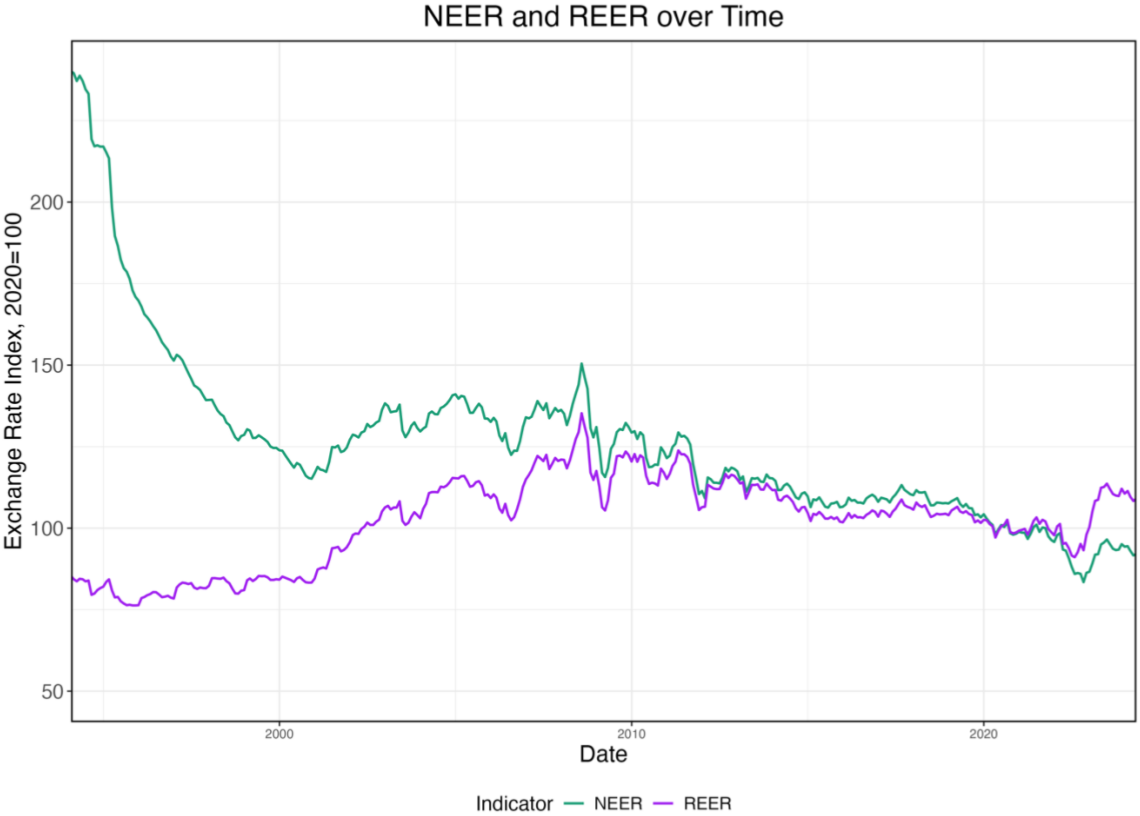
Additional Figure 3.



Additional Figure 3. shows the current account balance and net foreign assets over time (in current USD). This graph has important insights, the current account position in principal, needs to be matched with net foreign wealth position (current account deficit with increase. Net foreign assets are comprised of the sum of assets held by the monetary authority and deposit money banks, less their foreign liabilities (World Bank, 2024B). The net foreign assets were provided in local currency unit (in HUF) therefore it had to be converted to USD to be comparable with current account balance.

Data source: World Bank (https://data.worldbank.org)

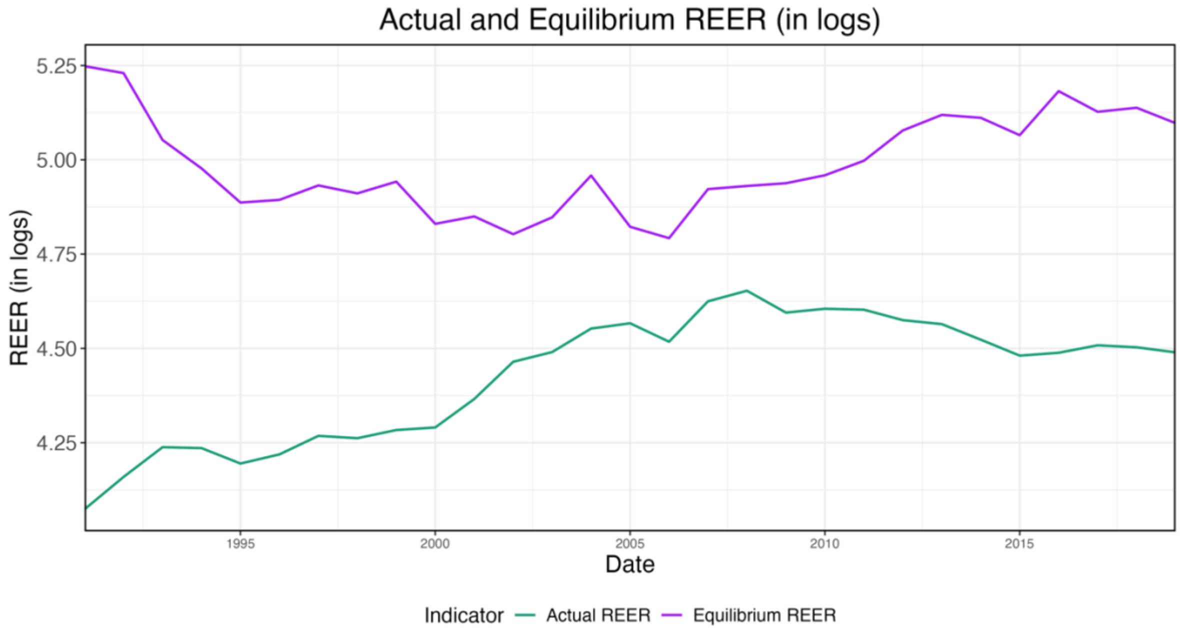
Additional Figure 4.



Additional Figure 4. Shows the Nominal Effective Exchange Rate (NEER) and the Real Effective Exchange of Hungary. Both measured against a broad basket (64 economies) of trading partners. Values are indexed to 2020 levels, first observations are from 1994 with monthly frequency.

Data source: Bank of International Settlements (https://data.bis.org/topics/EER/BIS,WS_EER,1.0/M.R.B.HU?additional_ts=BIS%2CWS_EER%2C1.0%255EM.N.B.HU)

Additional Figure 5.



Additional Figure 5. Shows the estimated EREER and the actual REER (both in logs). The estimation technique, statistical aspects and the relative strengths and weaknesses of the results are discussed in the main body of the study at Chatper 2.

Data source for the REER is the Federal Reserve Bank St. Louis, the EREER is estimated: https://fred.stlouisfed.org

Additional Table 2.

ADF Test for UCIP

	Test	Statistic	Lag.Order	p.value	Alternative.Hypothesis
Dickey-Fuller	Augmented Dickey-Fuller Test	-8.180	7	0.010	stationary

Additional Table 2. shows the Augmented Dickey-Fuller (ADF) test on the residuals stationarity of the OLS model on UCIP (Table 2., Figure 7.). According to the test, the residuals are stationary.

Additional Table 3.

ADF Test for IFE

	Test	Statistic	Lag.Order	p.value	Alternative.Hypothesis
Dickey-Fuller	Augmented Dickey-Fuller Test	-8.255	7	0.010	stationary

Additional Table 3. shows the Augmented Dickey-Fuller (ADF) test on the residuals stationarity of the OLS model on IFE (Table 3., Figure 9.). According to the test, the residuals are stationary.

Additional Table 2.

ADF Test for UCIP

	Test	Statistic	Lag.Order	p.value	Alternative.Hypothesis
Dickey-Fuller	Augmented Dickey-Fuller Test	-8.180	7	0.010	stationary

Additional Table 2. shows the Augmented Dickey-Fuller (ADF) test on the residuals stationarity of the OLS model on UCIP (Table 2., Figure 7.). According to the test, the residuals are stationary.

Additional Table 3.

ADF Test for IFE

	Test	Statistic	Lag.Order	p.value	Alternative.Hypothesis
Dickey-Fuller	Augmented Dickey-Fuller Test	-8.255	7	0.010	stationary

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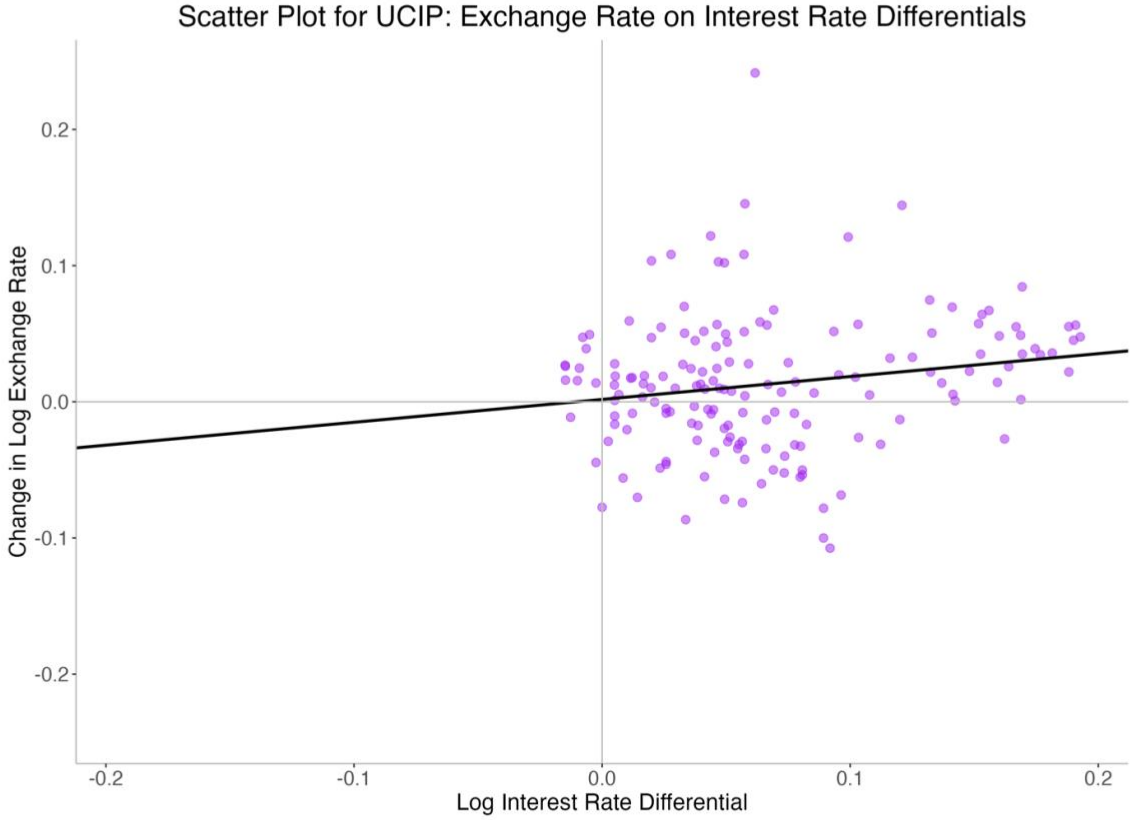
Additional Figure 6.



Additional Table 4.

OLS model for UCIP

	Dependent variable:
	Change_log_Exchange_Rate
Log_Interest_Rate_Differential	0.168**
	(0.072)
Constant	0.002
	(0.006)
Observations	160
R^2	0.033
Adjusted R^2	0.027
Residual Std. Error	0.050 (df = 158)
F Statistic	5.455** (df = 1; 158)
Note:	*p<0.1; **p<0.05; ***p<0.01

Additional Table 4. shows the quarterly UCIP estimation results from and OLS model. The estimated beta coefficient is significant at the 5% level, the constant term is not significant. The beta coefficient in the quarterly estimates are higher than those in the monthly model (**Table 2.**). **Aditional Figure 6.** shows the slope of the linear line that is fitted to the scatter plot.
Data source: Federal Reserve Bank of St. Louis https://fred.stlouisfed.org

Additional Table 5.

OLS Supply-Demand Model for Hungarian Currency

	Dependent variable:
	log_Exchange_Rate_diff
log_US_Real_GDP_diff	1.080
	(0.771)
US_Interest_Rate_diff	1.583
	(1.472)
log_US_Stock_Price_diff	-0.297^{***}
	(0.106)
US_Inflation_Rate_diff	0.270
	(0.594)
log_HU_Stock_Price_diff	-0.082
	(0.072)
HU_Interest_Rate_diff	1.990^{**}
	(0.899)
HU_Inflation_Rate_diff	-0.704^{**}
	(0.284)
log_HU_Real_GDP_diff	-0.404
	(0.433)
log_Expected_Exchange_Rate_diff	0.762^{***}
	(0.171)
Constant	0.002
	(0.005)
Observations	96
R^2	0.505
Adjusted R^2	0.453
Residual Std. Error	0.041 (df = 86)
F Statistic	9.759^{***} (df = 9; 86)
Note:	$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Additional Table 5. contains the coefficients of the Supply-Demand model in Chapter 2. Despite the coefficients reaffirm the direction of regressors and the outcome (some with high significance) due to potential serial correlation and time series processes, which the OLS linear framework cannot address, the results are considered reliable. Based on the Durbin – Watson test below, I face significant serial correlation that is not consistent with OLS.

Durbin – Watson test

	Test_Statistic	P_Value
DW	1.527	0.004

Additional Table 6.

Test Statistics and Critical Values

Statistic	N	Mean	St. Dev.	Min	Max
Test_Statistics	10	127.95	136.53	6.92	442.87
Critical_Values_10pct	10	111.46	84.21	10.49	256.72
Critical_Values_5pct	10	116.04	85.93	12.25	263.42
Critical_Values_1pct	10	125.46	89.65	16.26	279.07

Eigenvalues

Statistic	N	Mean	St. Dev.	Min	Max
Eigenvalues	11	0.28	0.25	0.00	0.86

Additional Table 6. Displays the cointegration relationship between the exchange rate and nine other supply-demand variables: E^e, Y^{US}, Y^{HU}, R^{US},R^{HU},S^{US},S^{HU}, π^{US},π^{HU}. Y^{HU} is the Hungarian real GDP; R^{US} is the interest rate in the US (T-bill); S^{US} is the stock price index in the US; E^e is the expected exchange rate, which is created from averaging exchange rate levels of previous four quarters (1 USD in HUF units); and finally, π^{US} is the inflation rate in the US. Y^{US} is the Hungarian real GDP; R^{HU} is the interest rate in Hungary on short term assets (matched to T-bill); S^{HU} is the stock price index in Hungary; and finally, π^{HU} is the inflation rate in Hungary. All those variables are quarterly, (log) first differences are taken.

The test statistic is highly significant (at the 1% level) which suggests long run equilibrium relationship and cointegration between the ten variables.

Additional Figure 7.

Additional Figure 6. Displays two plots, above the monthly excess returns on the Hungarian market (converted into US Dollars) and the US market. The plot below shows the fitted excess returns in Hungarian markets (converted to US Dollars, measured against the US risk-free, and adjusted to volatility) vs the actual excess returns in of Hungarian markets in US Dollars.